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Los Angeles District

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SANTA ANA RIVER BASIN, CALIFORNIA

AD-A204 544

Santa Ana River

Design Memorandum No. 1

PHASE II GDM ON THE SANTA ANA RIVER MAINSTEM including Santiago Creek

VOLUME 3
LOWER SANTA ANA RIVER (PRADO DAM TO PACIFIC OCEAN)

89 2 2 005

August 1988

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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4. TITLE (and Subtitle) Phase II GDM on the Santa Ana River Mainstem Including Santiago Creek Volume 3, Lower Santa Ana River (Prado Dam to Pacific Ocean)		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

- Drainage Area
- River Gradient
- Design Discharge
- Channel Improvements
- Drop Structures
- Land Acquisition

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This volume accompanies the Main Report and Supplemental Environmental Impact Statement for the Phase II General Design Memorandum for the Santa Ana River Mainstem including Santiago Creek and contains the general design for the Santa Ana River from Prado Dam to the Pacific Ocean.

SYLLABUS

This volume accompanies the Main Report and Supplemental Environmental Impact Statement for the Phase II General Design Memorandum for the Santa Ana River Mainstem including Santiago Creek and contains the general design for the Santa Ana River from Prado Dam to the Pacific Ocean.

The recommended plan will convey design outflows of 30,000 ft^3/s from Prado Dam to 47,000 ft^3/s at the Pacific Ocean. The project consists of acquisition of the post project overflow area along 8 miles of river just downstream of Prado Dam (Prado Dam to Weir Canyon Road) and 23 miles of improved channel (Weir Canyon to the Ocean). The reach from Prado Dam to Weir Canyon would remain in a natural rural condition for wildlife and open space value. The improved channel will consist of sections of trapezoidal riprap or grouted riprap channel, trapezoidal concrete-lined channel and rectangular concrete-lined channel. The ocean outlet will consist of rock mounded jetties. In addition, the Greenville-Banning Channel would be modified to join the Santa Ana River about 1 mile upstream of the Pacific Ocean. Talbert Channel will be relocated 1,000 feet upcoast from its present location to accommodate widening of the Santa Ana River at the ocean. The channel access and maintenance roads would be incorporated into the overall recreational trail system for the entire river. A 92-acre marsh will be restored at the mouth of the river for the preservation and enhancement of wildlife.

The estimated total project first cost is $365,000,000 including preconstruction engineering and design. Average annual charges will include $595,000 for channel operation and maintenance and $50,000 for recreational maintenance. Preconstruction cost for engineering and design in the amount of $10,550,000 for the lower channel includes engineering and design costs previously expended and anticipated funding allocation for preparing plans and specifications in FY 1989 has been expended to date. The project economic data is presented in Volume 9, Economics and Public Comment and Response.

PHASE I GDM LISTING OF VOLUMES

Main Report and Supplemental Environmental Impact Statement

Volume 1	Seven Oaks Dam
Volume 2	Prado Dam
Volume 3	Lower Santa Ana River (Prado Dam to Pacific Ocean)
Volume 4	Mill Creek Levee
Volume 5	Oak Street Drain
Volume 6	Santiago Creek
Volume 7	Hydrology
Volume 8	Environmental
Volume 9	Economics and Public Comment and Response

PERTINENT DATA
Lower Santa Ana River Channel
(Prado Dam to Pacific Ocean)

I.	Drainage Area:		
	a. Total Drainage Basin	2,450	mi^2
	b. Basin above Prado Dam	2,255	mi^2
II.	River Gradient (below Prado):		
	Santa Ana Canyon to Pacific Ocean	15	feet/mile
III.	Design Discharge:		
	a. Santa Ana Canyon	30,000-37,000	ft^3/s
	b. Weir Canyon to Pacific Ocean	38,000-47,000	ft^3/s
IV.	Channel Improvements:		
	a. Pacific Ocean to Fairview Channel (Stations 7+60 to 150+32)	Soft Bottom-Trapezoidal Riprap Side Slopes	
	b. Fairview Channel to San Diego Freeway (Stations 150+32 to 273+00)	Concrete Rectangular	
	c. San Diego Freeway to Edinger Avenue (Stations 273+00 to 393+50)	Concrete Trapezoidal	
	d. Edinger to River View Golf Course (Inlet) (Stations 393+50 to 535+80)	Concrete Trapezoidal	
	e. River View Golf Course (Inlet) to Orange Freeway (Stations 535+80 to 689+85)	Soft Bottom-Trapezoidal Riprap Side Slope	
	f. Orange Freeway to Glassell Street (Stations 689+85 to 865+15)	Soft Bottom-Trapezoidal Riprap Side Slope	
	g. Glassell Street to Imperial Highway (Stations 865+15 to 1069+10)	Soft-Bottom-Trapezoidal Riprap Side Slope	
	h. Imperial Highway to Weir Canyon Road (Inlet) (Stations 1069+10 to 1218+20)	Soft Bottom-Trapezoidal Riprap Side Slope	
	i. Weir Canyon Road (Inlet) to Corona Freeway (Prado Dam) (Stations 1218+20 to 1607+50)	Intermitent Bank Protection	

j.	Greenville-Banning Channel (Stations 9+50 to 177+00)	Concrete Rectangular and Trapezoidal	
k.	Marsh Restoration	Grading and Planting	
V.	Project Length:		
a.	Canyon Open Space	7.4	miles
b.	Trapezoidal Riprap Channel	12.9	miles
c.	Trapezoidal Concrete Channel	5.0	miles
d.	Rectangular Concrete Channel	2.4	miles
e.	Trapezoidal Riprap Channel (Ocean)	2.6	miles
f.	Trapezoidal Outlet Channel and Jetty	750	feet
VI.	Channel Width:	Varies 160-450	feet
VII.	Drop Structures:		
a.	To be modified	11	each
b.	New	3	each
VIII.	Total Bridges:	42	
a.	Highway Bridges	35	each
	(1) Bridges to be replaced	2	each
	(2) Bridges to be modified	26	each
	(3) Bridges to remain	4	each
	(4) Bridges by others	3	each
b.	Railroad Bridges	5	each
	(1) To be modified	4	each
	(2) To remain	1	each
c.	Bicycle Bridges		
	(1) Extended	1	each
	(2) Remain in place	1	each
IX.	Land Acquisition - Santa Ana Canyon Area	1123	Acres

Greenville-Banning Channel

I.	Channel Length: Confluence Santa Ana River to Victoria St.	3.2	miles
II.	Design Discharge:	5000-5800	ft^3/sec
III.	Rectangular Concrete Channel Width:	50-60	feet
IV.	Bridges:		
a.	Highway Bridges	2	each
	(1) Bridge to remain	1	each
	(2) Bridge to be modified	1	each

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B.	Coastal Design
C.	Sediment Transport Analyses
D.	Recreation
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I. INTRODUCTION

Authorization

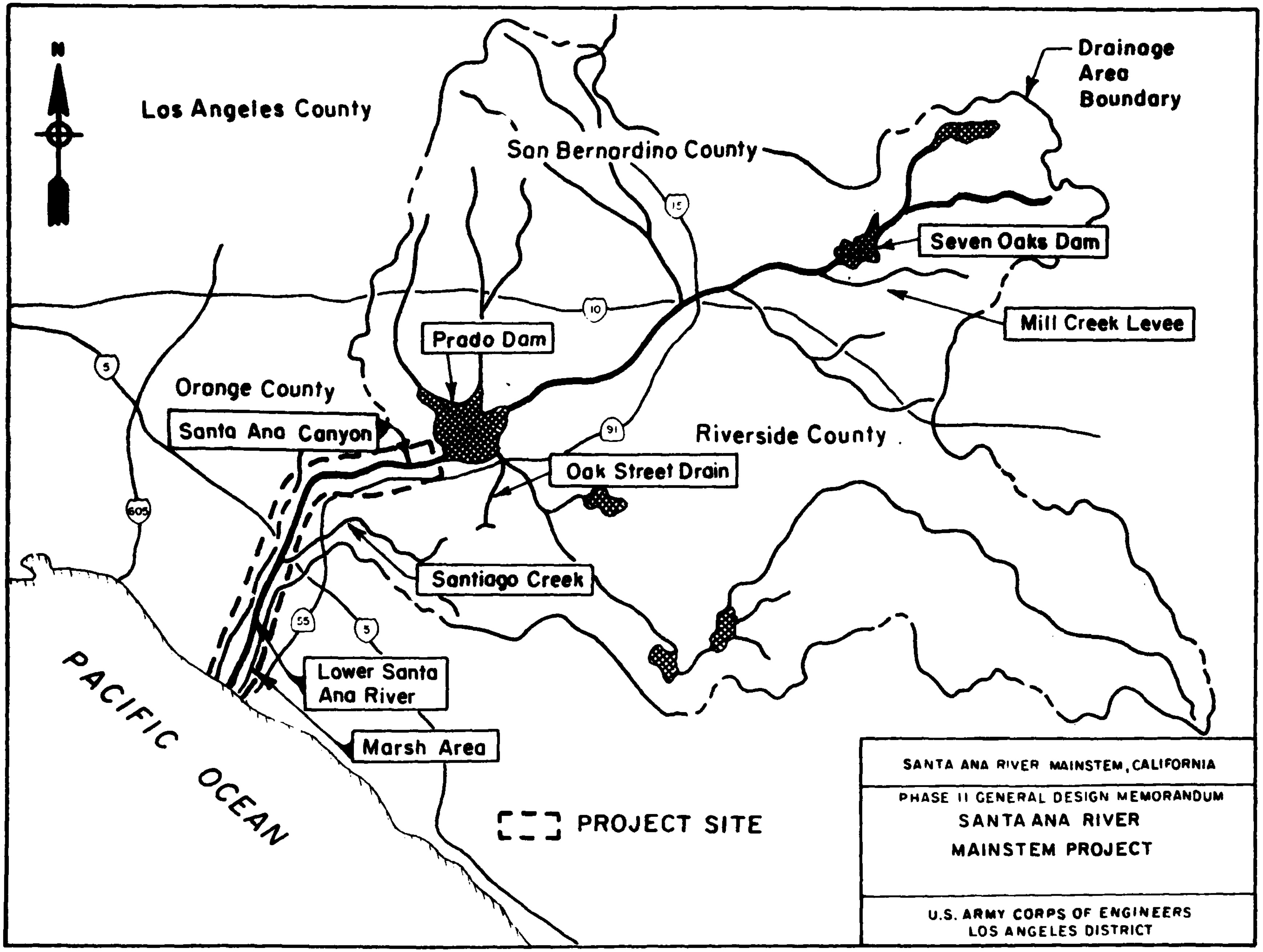
1-01 Construction authorization for the project is contained in the Water Resources Development Act of 1986 (99th Congress 2nd Session, P.L. 99-662). The project for flood control is contained in the report of the Chief of Engineers for the Santa Ana River Mainstem, including Santiago Creek, California dated January 15, 1982, except that in lieu of the Mentone Dam feature of the project, the Secretary is authorized to plan, design and construct a flood control storage dam on the upper Santa Ana River. The full authorization language is presented in the Main Report.

Scope and Purpose of Report

1-02 The primary purpose of the authorized project is to provide protection against floods and debris in the overflow area. With the enlargement of Prado Dam Reservoir, the recommended channel improvements along with the acquisition of an interest in the post project overflow area between Prado Dam and Weir Canyon Road will permit an increase in maximum operation releases from Prado Dam. The scope of post-authorization studies described in this volume of the memorandum includes establishment of the general and coordinated design of the recommended flood control improvements between Prado Dam and the Pacific Ocean. Phase II GDM provides the basis for: (1) a determination for the project rights-of-way and easements, (2) updating the project costs, (3) a current assessment of environmental and social effects, and (4) preparation of contract plans and specifications.

Local Cooperation

1-03 The division of Federal and non-Federal responsibilities for local cooperation are outlined in the Main Report.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Los Angeles County
San Bernardino County
Drainage
Area
Boundary
Seven Oaks Dam
Mill Creek Levee
Prado Dam
Orange County
Santa Ana Canyon
Riverside County
Oak Street Drain
Santiago Creek
Lower Santa
Ana River
Marsh Area
PACIFIC OCEAN
PROJECT SITE
5
605
10
15
91
55
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
SANTA ANA RIVER
MAINSTEM PROJECT
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE I

II. PROJECT PLAN

Description of the Project Area

2-01 The 2,450-mi^2 Santa Ana River Basin (fig. 1) contains the largest river system in Southern California. The Santa Ana Mountains and Chino Hills separate the upper and lower drainage basins in the vicinity of Prado Dam. In the lower basin, the Santa Ana Mountains (over 5,000 feet) stand in contrast to the rolling Chino Hills (1,780 feet). The lower basin occupies about 200 mi^2 and the coastal plains about 70 mi^2. The relatively flat coastal plain areas are mainly committed to urban use and any remaining open spaces are few in number and small in size. Over two million people live and work within the floodplain downstream of Prado Dam. The cities of Yorba Linda, Anaheim, Santa Ana, Huntington Beach, Orange, Newport, Fountain Valley, Westminster, Stanton, Costa Mesa, Buena Park, and Fullerton lie wholly or partly within the overflow area from a standard project flood. Photos 1 through 8 show the existing Santa Ana River channel from the mouth (at Pacific Ocean) upstream to Prado Dam.

Existing Flood Control Facilties

2-02 The existing flood control improvements built by local interests and the Corps of Engineers along the Lower Santa Ana River would reduce damages from small floods, but provide an insufficient level of protection for the highly urbanized Lower Santa Ana River floodplain.

2-03 The lower basin is currently provided with limited protection by the Prado Dam and Reservoir which were completed in 1941. Prado Dam presently offers only 70-year flood protection. Floods larger than 70-year frequency would result in uncontrolled spillway flows.

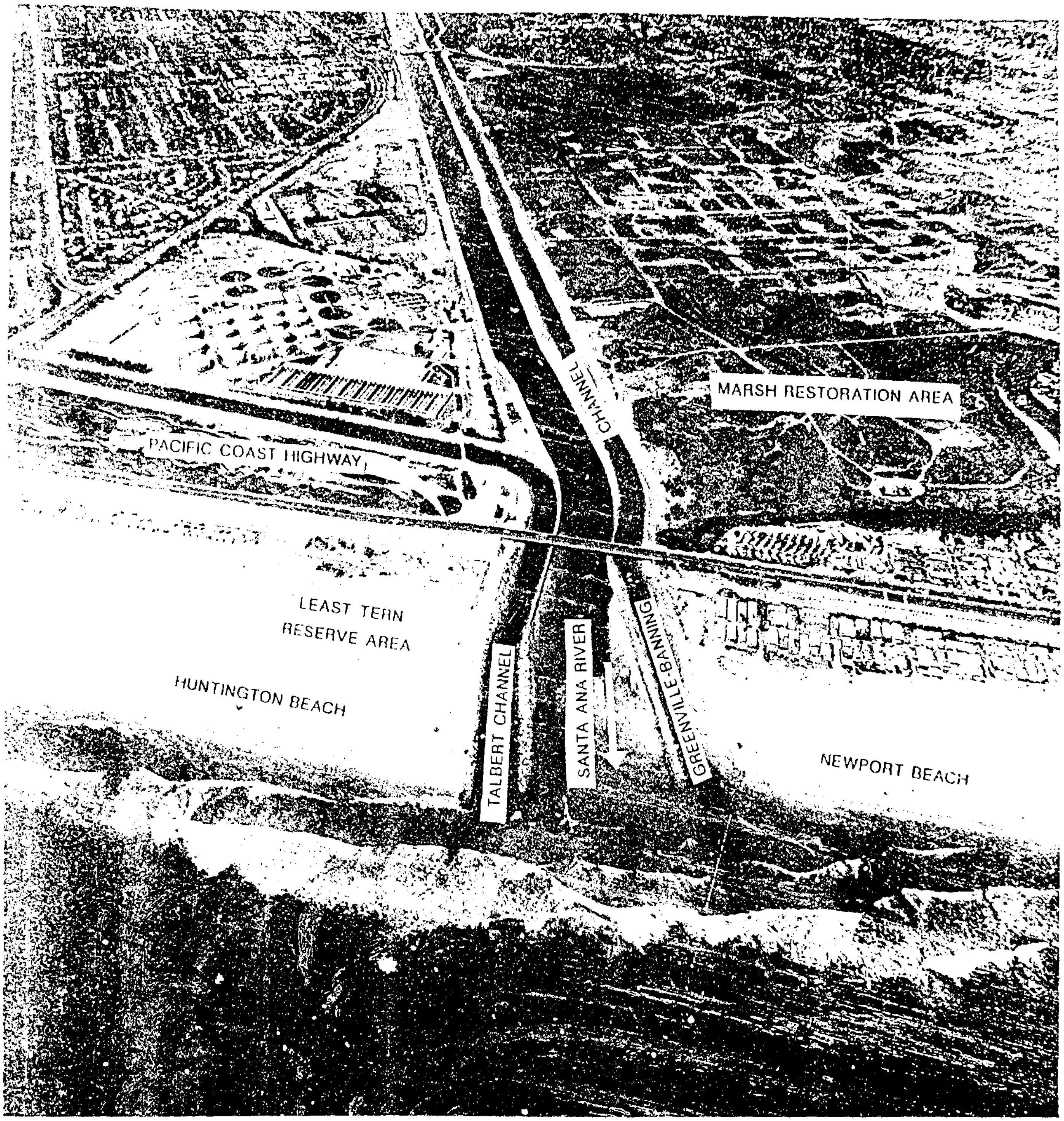


PHOTO 1: LOOKING UPSTREAM FROM MOUTH. LEAST TERN NESTING COLONY TO THE LEFT OF TALBERT CHANNEL.

PHOTO 2 LOOKING UPSTREAM NEAR SAN DIEGO FREEWAY. FREEWAY BRIDGE CONSTRAINS CHANNEL WIDTH; URBANIZATION AND SEWAGE PLANT CONSTRAINTS. (5 MILES U/S).

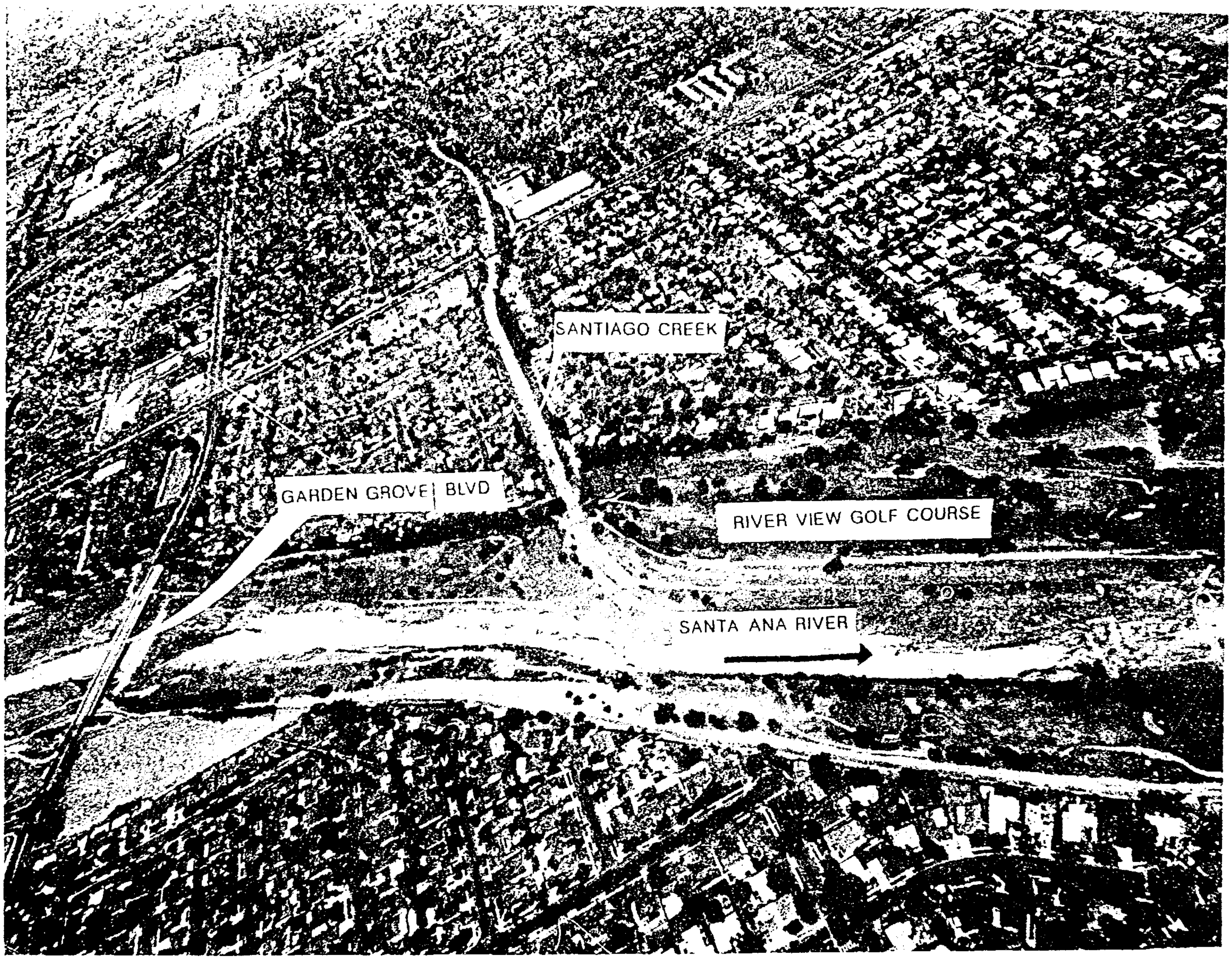


PHOTO 3: LOOKING EASTERLY AT THE CONFLUENCE OF SANTA ANA WITH SANTIAGO CREEK.
RIVER VIEW GOLF COURSE IS THE FOREGROUND AND IN THE RIVER CHANNEL. (10 MILES U/S)

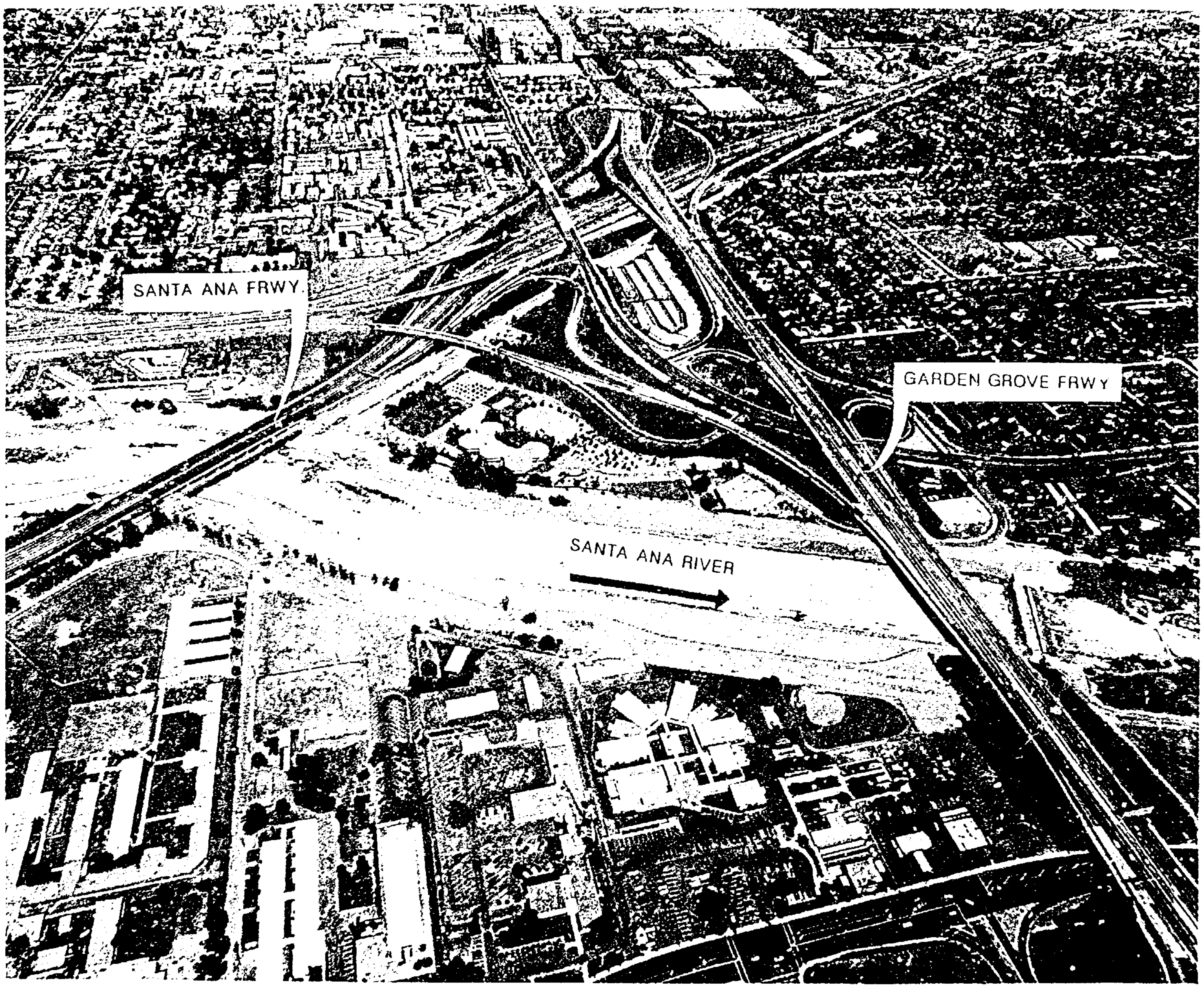


PHOTO 4: LOOKING NORTHEASTERLY. SANTA ANA RIVER AT THE INTERSECTION OF SANTA ANA AND GARDEN GROVE FREEWAYS. (12 MILES U/S)

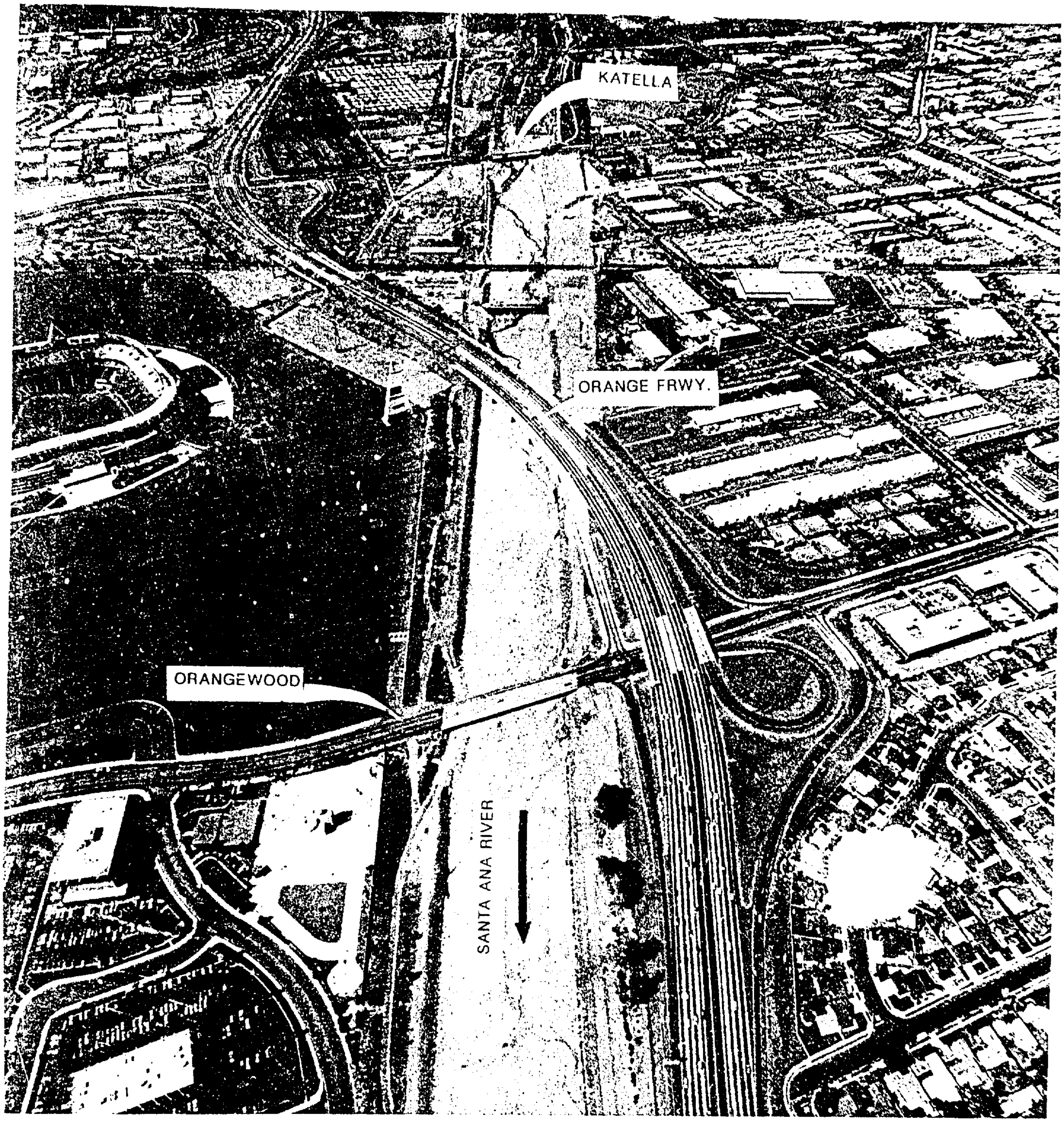


PHOTO 5: LOOKING UPSTREAM ALONG SANTA ANA RIVER. CROSSING BY ORANGE FREEWAY. (13 MILES U/S)

PHOTO 6: LOOKING UPSTREAM OF RIVER. ORANGE COUNTY WATER DISTRICT'S PERCOLATION BASINS ARE LOCATED LEFT OF RIVER CHANNEL. (17 MILES U/S)

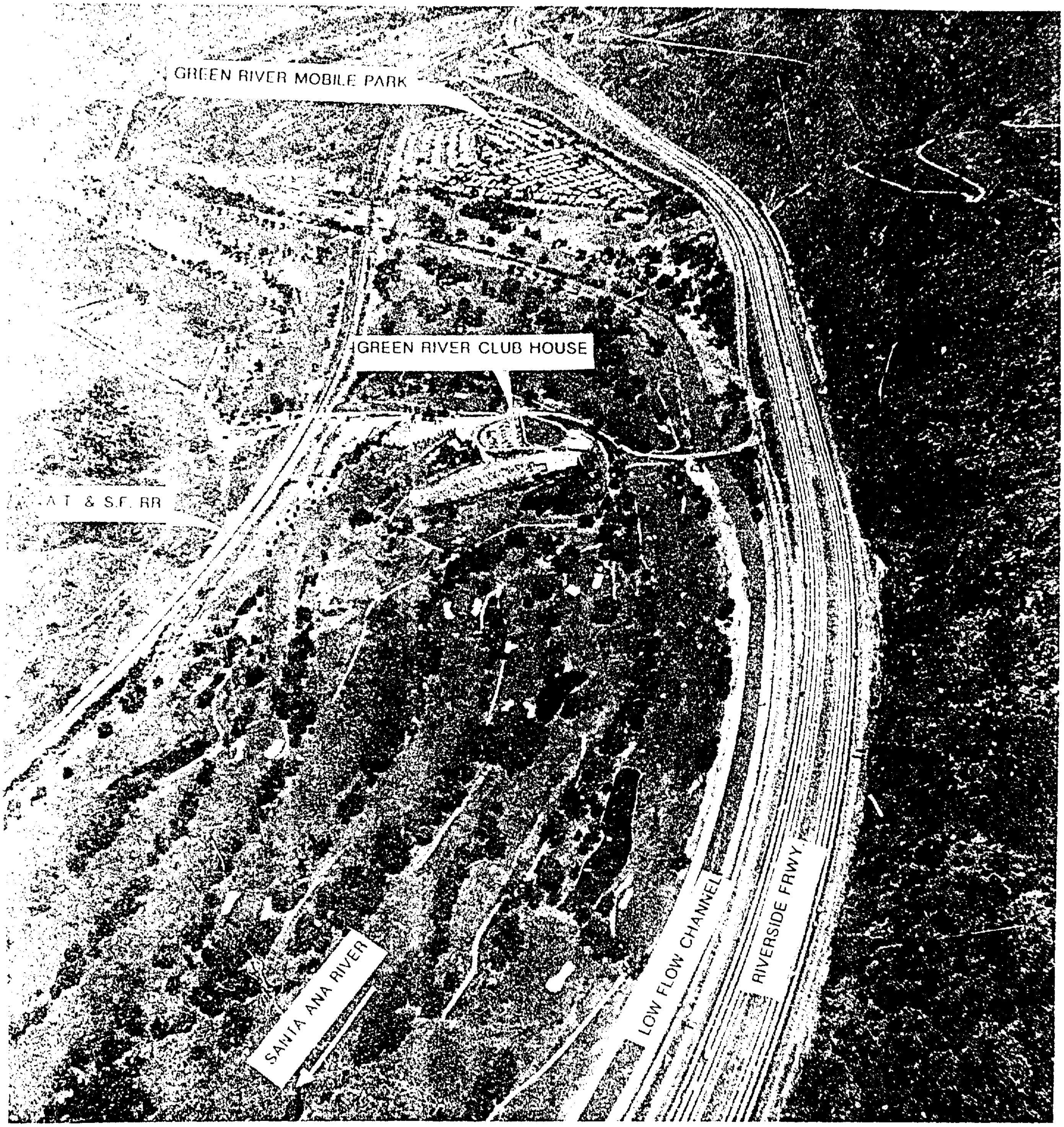


PHOTO 7: LOOKING UPSTREAM THROUGH SANTA ANA RIVER CANYON. GREEN RIVER GOLF COURSE IN FOREGROUND IS RIVER STREAMBED. LOW FLOW CHANNEL IS ADJACENT TO FREEWAY. (28 MILES U/S)

PHOTO: 8 LOOKING UPSTREAM OF RIVER CANYON. PRADO DAM AND SPILLWAY AT UPPER PORTION OF PHOTO GRAPH. (30 MILES U/S)

2-04 The Santa Ana River between Prado Dam and the Pacific Ocean is approximately 30.5 miles in length. The upstream 2.5 miles are located in Riverside County, and the remaining 28 miles are within the Orange County limits. The river winds through the narrow and relatively undeveloped Santa Ana Canyon for a distance of about 10 miles before it turns southwest into the alluvial plain of the metropolitan area of Orange County. Over the years, the Lower Santa Ana River has been improved by local interests from the Santa Ana Canyon to the Pacific Ocean. Typical cross sections of existing channel improvements are shown on plate 70.

PRADO DAM TO WEIR CANYON ROAD

2-05 Much of the upper reach of the river is unimproved. Within the Santa Ana Canyon, slope protection has been constructed by various local entities at freeway and railroad embankments, and at existing private developments adjoining the river. Slope protection for freeway embankments includes riprap and soil cemented side slopes. The private developments have constructed riprap or grouted riprap slope protection. The AT&SF Railroad has constructed riprap slope protection and installed sheet piles at critical areas. Within the Santa Ana Canyon, flows enter an improved channel immediately upstream from the Weir Canyon Road bridge. The Green River Golf Course, a 345-acre, 36-hole golf course is located within the streambed of the Canyon reach. The improved low-flow channel through the golf course will convey about 2,000 ft^3/sec.

WEIR CANYON TO KATELLA AVENUE

2-06 Existing channel improvements begin in the vicinity of Weir Canyon Road. Just upstream from Weir Canyon Road bridge, the Savi Ranch development has constructed a levee embankment for flood protection. From Weir Canyon Road downstream to a point about 1,100 feet south of Katella Avenue, a distance of 9.6 miles, the existing channel is trapezoidal in cross section with a soft-bottom invert and stone revetted side slopes of 1V to 2H. The channel has a base width ranging from 300 feet at the upstream end to 320 feet near Katella Avenue, and channel depths ranging from 12 to 18.5 feet. Within this reach there are eight drop structures from 4.5 to 9.7 feet in height which function as hydraulic energy dissipators and streambed stabilizers. A portion of river flows are diverted into water spreading basins along the right bank for ground water recharge.

KATELLA AVENUE TO GARDEN GROVE FREEWAY

2-07 Downstream from Katella Avenue to the Garden Grove Freeway, a channel reach of 2.1 miles, the earth-bottom trapezoidal channel has a base width varying between 240 to 270 feet, and side slopes changing from 1V on 1.5H to 1V on 3H. The upstream 500 feet of channel with steeper side slopes has concrete side slope protection, and the remaining reach of this channel has stone-revetted side slopes. Within the revetted reach of channel, there are two drop structures, approximately 1 mile apart, constructed by the Orange County Environmental Management Agency (OCEMA).

GARDEN GROVE FREEWAY TO 17TH STREET

2-08 The easterly side of the river is improved with a grouted rock revetment running from the Santiago Creek confluence to approximately 500 feet north of 17th Street, a distance of approximately 3,600 feet. There is a reinforced concrete lining on both sides of the river from 17th Street to the point where it joins the revetted side slope. The westerly side has approximately 700 feet of grouted riprap at the confluence with Santiago Creek; the remainder between the concrete lining north of 17th Street and Garden Grove Boulevard has minimal protection of a pipe and wire revetment installed after the 1938 flood. The golf course turf provides no stabilization except for very minor annual floods. The bicycle trail crossing near 17th Street functions as a grade stabilizer with heavy rock revetment placed as a protective measure during the floods of 1978 and 1980. However, it is not a drop structure. There is also a grouted rock stabilizer at the downstream side of the Garden Grove Boulevard bridge.

17TH STREET TO ADAMS AVENUE

2-09 From approximately 1,200 feet upstream from 17th Street to about 3,000 feet downstream from Adams Avenue, a reach of 7.4 miles, the existing Santa Ana River is a channel with soft bottom, trapezoidal cross section, and heights ranging from 13 to 17 feet. The side slopes, varying from 1V to 1.5H to 1V on 2H, are protected with reinforced concrete. The base width of the channel varies significantly within this reach, ranging from 160 to 250 feet.

ADAMS AVENUE TO PACIFIC COAST HIGHWAY

2-10 Downstream of Adams Avenue for a distance of 1.8 miles, the base width of the existing soft-bottom trapezoidal channel is 160 feet. The channel height is approximately 16.5 feet with side slopes of about 1V on 3H. About 0.6 miles upstream from the Pacific Coast Highway, the improved channel has either a concrete or grouted stone invert. The channel width is 160 feet except at the downstream 0.2 miles where the width changes to 180 feet. The channel cross section transitions from trapezoidal to rectangular as it flows downstream. Wall heights for both type of channel sections are approximately 16 feet. The 564 feet long channel transition and downstream vertical channel walls are constructed with reinforced concrete. The existing Greenville-Banning Channel is located adjacent and parallel to the Santa Ana River channel in this reach.

SANTA ANA RIVER OUTLET

Channel Configuration

2-11 The outlet channel of the Santa Ana River is located south of Pacific Coast Highway in Huntington Beach where the river discharges into the Pacific Ocean. The outlet channel consists of a transition section, from rectangular concrete tc trapezoidal stone jetty. The

700-foot-long outlet channel has a soft-bottom invert with a base width varying from 180 to 316 feet. The existing Santa Ana River mouth includes the Greenville-Banning Channel to the southeast, the Talbert Channel to the northwest, and the Santa Ana River in between the two. Near the ocean outlet the channel widths are approximately 150, 300, and 80 feet for the Greenville-Banning Channel, the Santa Ana River, and the Talbert Channel, respectively. The width of the Santa Ana River varies from 160 to 180 feet upstream from the Pacific Coast Highway. The as-built invert slope of the Santa Ana River (0.001 to 0.003) is generally greater than that of the Talbert Channel (0.0005 to 0.0009) and the Greenville-Banning Channel (0.0005).

Jetty Configuration

2-12 The existing outlets of the Talbert Channel, Santa Ana River, and Greenville-Banning Channel are contiguous and are stabilized by four jetties: (1) an exterior jetty on the northwest side of the Talbert Channel ("Northwest Jetty"), (2) an interior jetty separating the Talbert Channel and the Santa Ana River, (3) an interior jetty separating the Santa Ana River and the Greenville-Banning Channel, and (4) an exterior jetty on the southeast side of the Greenville-Banning Channel ("Southeast Jetty"). The jetties are not orthogonal (perpendicular) to the shoreline, but angled slightly to the southeast. The jetty lengths also diminish with distance to the southeast, the net result being an offset configuration in which the Northwest Jetty extends about 150 feet further offshore than the Southeast Jetty.

2-13 Each jetty is of rubble mound construction. The jetties are in sound condition despite the apparent displacement of several large rocks from the tip of the Northwest Jetty. The existing rock will be reused for new jetty construction.

The Flood Problem

2-14 Although portions of the existing Santa Ana River channel can convey flows having a capacity ranging from 30,000 to 40,000 ft^3/sec, severe erosion of the unlined channel invert would occur if more than 5,000 ft^3/sec is released from Prado Dam. Discharge of more than 5,000 ft^3/sec from the dam would undermine the toe of channel embankments and would erode the foundation materials underneath the piers of many bridges. The Orange County Environment Management Agency (OCEMA) has been improving the capability of the Santa Ana River channel during the last 30 years, but the invert of the entire channel system must be stabilized and the channel banks strengthened before the channel can convey the design flood. The spillway outflows from Prado Dam under present conditions are 50,000 ft^3/sec for the 100-year flood event and 160,000 ft^3/sec for the 200-year flood event. These flood events would not be contained by the existing channel improvements and would cause widespread flooding within the lower river area. With Prado Dam and Santa Ana River improvements in place, peak discharge would be reduced to 30,000 ft^3/sec.

Phase I Authorized Plan

GENERAL

2-15 The Phase I authorized channel improvements for the Lower Santa Ana River were developed in consideration of existing channel conditions and rights-of-way. In general, six methods of improvement were proposed for various reaches of the channel: (1) intermittent levee and bank protection within the Santa Ana River Canyon to Weir Canyon Road; (2) trapezoidal earth-bottom channel with revetted side slopes, (3) combination levee and parapet walls, (4) rectangular concrete-lined channel, (5) rectangular concrete wall channel with soft bottom downstream to the Pacific Ocean; and (6) rock jetties at the ocean outlet.

PRADO DAM TO WEIR CANYON BRIDGE

2-16 The authorized plan for the 8-mile reach of canyon was to acquire and manage lands within the post project overflow area for wildlife and open space values. Improvements in the canyon reach included intermittent levee and bank protection along the upstream 7.6 miles of the Santa Ana River. The bank protection consisted of stone revetment with a thickness varying from 12 to 24 inches, placed at various locations adjacent to the Riverside Freeway along the upper 3.3 miles of the river. Another 4,700 feet of 18-inch grouted stone revetment was proposed at a mobile home park where excessive channel scouring was anticipated.

SANTA ANA RIVER CHANNEL--WEIR CANYON TO PACIFIC OCEAN

2-17 Downstream from Weir Canyon to the Pacific Ocean, the remaining 23 miles of the existing river channel were proposed to be widened, deepened, and reconstructed to carry the project design flow of about 38,000-47,000 ft^3/sec. Channel improvements authorized generally consisted of four types of channel: (1) soft-bottom trapezoidal channel with revetted side slopes, (2) hard-bottom concrete rectangular channel, and (3) soft-bottom concrete rectangular channel and lastly, (4) a channel configuration with levee and parapet walls.

2-18 Starting with the inlet levee located immediately upstream from Weir Canyon Road (sta. 1216+30) to the vicinity of River View Golf Course (approximate sta. 535+30) the first 12.0 miles of existing trapezoidal soft bottom channel would have been improved by deepening the invert and raising the banks. The channel invert would remain unlined to allow groundwater recharge, but the channel slopes would be revetted with 18 inches of grouted stone.

2-19 Within this reach, 20 stabilizer structures would have been constructed at approximately 2,000-foot intervals in order to stabilize the channel invert during floodflow. The 11 existing drop structures would have been modified and three new drop structures would have been built at critical locations to reduce the velocity of floodflows. All of the new and modified drop structures would have been constructed with reinforced concrete.

2-20 At the River View Golf Course, the channel in Phase I GDM was irregular in cross section. A vertical reinforced concrete floodwall was planned to be constructed along the eastern boundary of the golf course to prevent floodwaters from breaking out of the golf course and flooding adjacent residences. Under this plan, the invert of the main channel would have remained in its existing natural condition and used as a portion of the golf course.

2-21 Downstream from the golf course in the vicinity of 17th Street to a point about 1,000 feet upstream from the San Diego Freeway, a reinforced concrete-lined trapezoidal channel was to be constructed. The 5.0-mile reach of channel would have had a base width ranging from 180 feet to 160 feet, and levee heights varying from 12.5 feet to 20.0 feet. The existing streambed would have been deepened by a maximum of 10 feet in order to carry the design floodflows.

2-22 The authorized channel improvement required eight street bridges and one railroad bridge to be reconstructed. In addition, the Slater Avenue bridge was to be modified to accommodate the design flows. A subdrainage system would have been required under the invert of the rectangular concrete channel.

2-23 The downstream 2.6 miles (sta. 150+32 to the Pacific Ocean) of the Phase I channel to Pacific Coast Highway was a soft bottom channel with vertical concrete walls. The width of the channel varied from 450 feet to 480 feet, and the height of channel was to be about 15 to 18 feet above the channel invert.

2-24 The authorized outlet channel structure was to be located immediately downstream from the Pacific Coast Highway where the Santa Ana River empties into the Pacific Ocean. The channel in this reach would have had a bottom width of 450 feet and a trapezoidal cross section. The outlet structure was to be a jetty section covered with a 48-inch layer of stone revetment over 12-inch filter material. The stone revetment would have been extended to a depth of 10 feet below the invert elevation. The height of channel walls above invert grade would range about 12 to 15 feet.

GREENVILLE-BANNING CHANNEL

2-25 The existing portion of Greenville-Banning Channel to be improved is an unpaved trapezoidal channel located parallel to the Santa Ana River channel. The limited improvements constructed by local interests have insufficient capacity for conveyance of major floods. The authorized Greenville-Banning Channel improvement was to be located adjacent to the east bank of the Santa Ana River channel. The improvement for the existing channel was to begin approximately 1,600 feet south of San Diego Freeway, and would have joined the Santa Ana River about 2,000 feet south of Victoria Street, a total distance of 3.3 miles. Due to urbanization along the channel, the major portion of the channel would have had a rectangular cross section with reinforced concrete invert and walls. The channel invert would have varied from 50 feet to 60 feet in width, the channel wall heights ranging from 13.5 feet to 17 feet. An upstream transition section would have joined

the improved rectangular channel with the existing trapezoidal channel. The merging of Greenville-Banning and Santa Ana River would have resulted in a widened Santa Ana River channel below Victoria Street. The widened channel would have affected about 5 acres of the west side of the Victoria Pond, a fresh water lagoon located to the east of the existing channel. The pond was to be relocated to the southeast and maintained to its approximate 13-acre size.

HUNTINGTON BEACH/TALBERT CHANNEL

2-26 The recommended relocation of the Talbert Channel was required due to realignment and widening of the proposed Santa Ana River channel mouth. The existing Talbert Channel was to be moved immediately to the west (upcoast) from its existing alignment. The portion of relocated channel was to be approximately 1,500 feet in length, with a trapezoidal cross section. The soft-bottom channel was to be designed for the 100-year runoff with a base width of about 160 feet.

SALT MARSH RESTORATION

2-27 Eight acres of salt marsh were to be purchased as mitigation for flood control improvements between Victoria Avenue and Pacific Coast Highway. In addition, about 84 acres of salt marsh, existing tidal channels, and an upland area were to be acquired, modified, and restored to enhance endangered species habitat. The marsh was to be modified by regrading, extending the existing channels, and replacing the existing tide gate with a more effective tide gate system in order to improve the overall tidal circulation in the wetland area. A 6-acre island for a least tern colony was to be constructed as part of the restoration.

The Plan Recommended in this Report

2-28 The plan recommended in this report is in basic accordance with the authorized plan. Detailed elements of the Phase I design were generally followed for the Phase II GDM. Deviations from the Phase I design were made upon reexamination of hydraulic considerations, economic feasibility and viability of construction. The major change has been to eliminate certain reaches of rectangular channels construction. A comparison of the authorized plan and Phase II recommended channel design are shown in Table II-1.

Table II-1. Comparison of Phase I and Phase II Channel Design, Lower Santa Ana River.

	Reach	Phase I	Phase II
1.	Pacific Ocean to Fairview Channel (Stas. 7+60 to 150+32)	Soft Bottom Vert.Conc. Wall	Soft Bottom-Trap W/Riprap S.S.
(1)	Marsh Restoration	Grading and Planting	No change
(1)	Talbert Channel	Soft Bottom-Trap w/Riprap S.S.	No change, but relocate to West
2.	Fairview Channel to San Diego Freeway (Stas. 150+32 to 273+00)	Rectangular Concrete	No Change
3.	San Diego Freeway to Edinger Ave. (Stas. 273+00 to 393+50)	Rectangular Concrete	Concrete Trap
4.	Edinger to River View Golf Course (Inlet) (Stas. 393+50 to 535+80)	Rectangular Concrete	Concrete Trap
5.	River View Golf Course (Inlet) to Orange Freeway (Stas. 535+80 to 689+85)	Flood Wall	Soft Bottom-Trap W/Riprap S.S. No Parapet Wall
6.	Orange Freeway to Glassell St. (Stas. 689+85 to 865+15)	Soft Bottom-Trap W/Riprap S.S.	No Change
7.	Glassell St. to Imperial Highway (Stas. 865+15 to 1069+10)	Soft-Bottom-Trap W/Riprap S.S.	No Change
8.	Imperial Hwy. to Weir Canyon Rd. (Inlet) (Stas. 1069+10 to 1218+20)	Soft Bottom-Trap W/Riprap S.S.	No Change
9.	Weir Canyon Road (Inlet) Corona Freeway (Prado Dam) (Stas. 1218+20 to 1607+50)	Intermittent Protection	Intermittent Protection*
10.	Greenville-Banning Channel (Stations 9+50 to 177+00)	Concrete Rect. & Trap	No Change

(1) Part of Reach 1.

*Existing Freeways, Railroad and private developments have provided their own embankment protection. Riprap levee protection is recommended at Green River Golf Course Adjacent to Mobile Park Homes.

2-29 Detailed descriptions of the recommended changes are as follows:

a. In the 8.1 miles of the Santa Ana River downstream from Prado Dam, where bank protection was to be provided, the proposed stone protection for the existing Highway 91 embankment will not be placed due to CALTRANS having constructed soil cement bank protection in the same locations as the authorized improvements and has future plans to provide additional protection. Private developments have also provided their own slope protection which was constructed in coordination with the local sponsors. In addition, approximately 380 acres of canyon lands, previously within the original floodplain that was to be acquired and designated for acquistion have been lost due to urban development leaving approximately 1,123 acres of canyon lands currently available for acquistion. Orange County has acquired 800 acres of the land to date.

b. Green River Golf Course. Due to overbank flows from Santa Ana River into the mobile homes located behind the Green River Golf Course, a levee was designed to contain the floodflows in the river. The levee will be located between station 1489+00 to 1515+00. The levee is designed with side slopes at 1V to 2H, and height between 3 feet to 8 feet. The top of levee will be 15 feet wide with the river side slope extending 18 feet below the existing channel thalweg and protected by 12 to 36 inches of riprap.

c. Highway 91 Embankment. CALTRANS has placed soil cement or riprap protection along various locations of the highway embankment adjacent to the Santa Ana River. With few exceptions, the existing slope protection has held well under various flow conditions. CALTRANS currently has plans to do additional slope protection work within this area. In addition, because outflows from Prado Dam under maximum design discharge condition would be reduced, slope protection for the existing highway embankments are not planned.

d. Weir Canyon Road Inlet. In the vicinity of Weir Canyon Road, the channel inlet required modification due to recent development in the area. The inlet will now tie into the existing Savi Ranch Development Levee on the south bank and the existing natural north bank. Downstream from Weir Canyon Road, portions of the south levee were recently improved by Orange County. Existing levee portions will be incorporated into the project where feasible, and would not be reconstructed. From Weir Canyon Road to the vicinity of the River View Golf Course all but one of the 13 drop structures will be provided with a parabolic drop design instead of the previous vertical drop. The parabolic drop structures were modeled at the Corps' Water Experiment Station (WES). The downstream toe of the drop structures will be protected with a stone-revetted apron. One drop structure will be grouted stone with a 1V on 2H sloping face. This drop structure will be located within the River View Golf Course at station 571+50 (pl. 34).

e. River View Golf Course. At the River View Golf Course, the Phase I GDM channel design of a low flow channel and floodwall behind the golf course did not accommodate the Santiago Creek confluence design. In addition, the original proposed floodwall located along a row of homes bordering the golf course was excessively high (8 to 10 feet) and would be objectionable to adjacent property owners with its obstruction of view. In order to accommodate the design of the Santiago Creek confluence, it was necessary to lower the Santa Ana River invert and add a drop structure immediately upstream from the confluence. An improved channel to carry the necessary flows through the golf course will be constructed. The channel is designed as a trapezoidal section with earth bottom and riprap side slopes. The channel construction will require removal of a number of greens and portions of fairway from the golf course.

f. Downstream Mainstem Channel. Downstream from the River View Golf Course at Edinger Avenue to about the San Diego Freeway, the channel cross sections has been changed from the Phase I rectangular concrete to a trapezoidal concrete channel, because of available rights-of-way and estimated lower construction costs. Further downstream, due to rights-of-way constraints, a concrete rectangular channel design was developed for the next 2 miles between the San Diego Freeway and Adams Avenue (sta. 273+00 to sta. 150+00). From Fairview Channel to the Pacific Ocean, the channel cross section has been changed from the Phase I rectangular concrete (T-wall) with soft bottom to stone-revetted trapezoidal channel with soft bottom. This change is based on available rights-of-way, constructability considerations and also lower construction costs.

g. Marsh Restoration. The marsh restoration design was accomplished and presented in a report entitled "Marsh Restoration, Lower Santa Ana River channel, Orange County, California", dated September 1987, by Simons & Li Associates. The design includes construction of a training dike within the Santa Ana River to improve tidal circulation to the 92-acre marsh restoration (located just upstream from the Pacific Coast Highway). Marsh restoration includes regrading, planting and the installation of new tide gates along the east bank of the Santa Ana River. Restoration plans for the proposed marsh have been coordinated with the appropriate resource agencies. Detailed discussion of the channel mouth design is contained in Section 5, Coastal Design.

h. Channel Outlet. The existing jetties are to be removed and replaced with new jetties. A training dike is added at the ocean outlet (downstream from Pacific Coast Highway Bridge) to assure less frequent closure of the mouth due to littoral drift and improve tidal flow and circulation for the salt marsh. Further description of the training dike is in the Coastal Design, Appendix B.

i. Talbert Channel. The Talbert Channel has been relocated about 1,000 feet further upcoast to the west to avoid impacts to the existing least tern nesting colony. Orange County has indicated they will design and construct the channel in advance of the mainstem project.

Consideration of Other Alternatives

2-30 A number of alternative design studies were considered during the development of the Phase II GDM. The following alternative studies were accomplished.

a. Concrete trapezoidal channel from the River View Golf Course to the San Diego Freeway.

   Phase I design for this reach was a concrete rectangular channel varying 16-19 feet high and 240-250 feet wide. This construction was estimated to be more costly than the concrete trapezoidal channel ultimately incorporated in the design of this reach.

b. Elimination of River View Golf Course parapet wall.

   Within this reach, the golf course is located within the riverbed of the channel. This portion of the river is also the confluence of Santiago Creek with Santa Ana River. Phase I design contained the riverflow between the west levee and a parapet wall along the east edge of the golf course. Due to the necessity to lower the invert of Santiago Creek confluence to join with Santa Ana River, the Santa Ana River channel invert had to be lowered. In addition, a new drop structure was required on Santa Ana River immediately upstream of confluence. Lowering of the channel invert allowed the mainstem channel to contain the design project discharge and eliminated the need for a parapet wall.

c. Trapezoidal stone revetted channel from Fairview Channel to the Pacific Coast Highway.

   Phase I design called for a vertical walled channel with earth bottom invert. A rocked revetted trapezoidal channel was designed to contain the design discharge without additional channel width.

d. Soft bottom retangular channel with concrete sheet pile walls from Fairview Channel to Pacific Coast Highway bridge.

   This proposal retained the Phase I channel design of a vertical wall rectangular channel by replacing the walls with vertical concrete sheet piles. The cost of this alternative was found to be slightly less than the original T-wall design. The vertical concrete cut-off wall was also eliminated in this design. Further studies (see c. above) resulted in the recommendation of the trapezoidal stone-revetted channel in this reach.

e. Reconstruction and/or modification of existing bridge structures with respect to the Phase II recommended channel design.

A review was made of all bridge crossings in an effort to lessen the cost of bridge reconstruction and modifications. Only two bridges were found to be necessary for reconstruction compared with 11 bridges in Phase I. Considerable savings were effected by a concerted effort to save as many bridges as possible.

f. Alternative to improve tidal circulation for the marsh restoration.

To provide additional tidal circulation to the marsh. Additional channel flows from Talbert Channel were considered. This required an extension of flows from the relocated Talbert Channel to the main channel by utilizing either the existing channel or a new reinforced concrete pipe outlet. This alternative was determined to be costly and unnecessary as the final design of the mainstem channel mouth will include construction of a training dike within the mainstem channel outlet that would adequately allow for tidal circulation to the marsh.

III. HYDROLOGY

General

3-01 This section provides a brief description of the Lower Santa Ana River Basin and presents the design discharges for the recommended channel on the mainstem. More detailed information on the development of the hydrology is given in Volume 7 of this GDM.

3-02 The Lower Santa Ana River basin from Prado Dam to the Pacific Ocean comprises about 200 mi^2, excluding about 19 mi^2 tributary to Carbon Canyon Creek above Carbon Canyon Dam. The Lower Santa Ana River (SAR) flows about 31 miles from Prado Dam through the Santa Ana Canyon and the cities of Yorba Linda, Anaheim, Orange, Santa Ana, Fountain Valley, Costa Mesa, and Huntington Beach before emptying into the Pacific Ocean. Approximately 60 percent of the drainage area below Prado Dam lies within the Santa Ana Mountains and the Chino Hills. This area is expected to remain in a natural undeveloped state during the life of the project. Most of the remaining area is in the coastal plain which extends southwestward to the Pacific Ocean and is heavily urbanized. This drainage area (fig. 2) is only a small part of the much larger urbanized overflow area of the Santa Ana River. Figures 3 through 6 show the location and boundaries of the drainage basin. Numerous tributaries contribute to the Santa Ana River within the watershed. The principal lower basin tributary is Santiago Creek, which rises to an elevation of 5,687 feet at Santiago Peak. Other tributaries include Wardlow Canyon, Aliso Canyon, Gypsum Canyon, Coal Canyon, Weir Canyon, Blue Mud Canyon, Walnut Canyon, and Carbon Canyon. Within the urbanized area downstream from Weir Canyon Road, there are approximately 150 drains and 4 pump stations also contributing flow to the Santa Ana River.

Mainstem Design Flood Peak Discharges

3-03 Table III-1 lists the design flood peak discharges (based on future conditions) at several locations along the Lower Santa Ana River as shown in figure 7. The design flood peak discharges on the Santa Ana River below Prado Dam are produced by a general storm critically centered above Prado Dam with contemporaneous rainfall from the same general storm falling on the drainage area below Prado Dam. This storm resulted in a outflow discharge of 30,000 ft^3/sec from Prado Dam, which was routed downstream and combined with the contemporaneous flow of downstream subareas to determine the design flood peak discharges at each location. A storm centered below Prado Dam, whether a local storm or a general storm, will not be more critical than the selected storm centered upstream from Prado Dam.

Table III-1. Design Flood Peak Discharges Along the Lower Santa Ana River.

Location	Station	Design Discharge (cfs)*
Prado Dam Outflow	1607+50	30,000
Downstream from:		
Wardlow Canyon	1603+10	31,000
Weir Canyon Road	1207+30	37,000
Imperial Highway	1065+61	38,000
Carbon Canyon Diversion Channel	846+25	40,000
Santa Ana Freeway	625+39	42,000
Santiago Creek	564+00	46,000
Hamilton Avenue	72+90	47,000
Pacific Ocean	16+95	47,000

*Based on general storm upstream from Prado Dam. Design discharges below Prado Dam are approximately a 190-year event.

Interior Flood Control

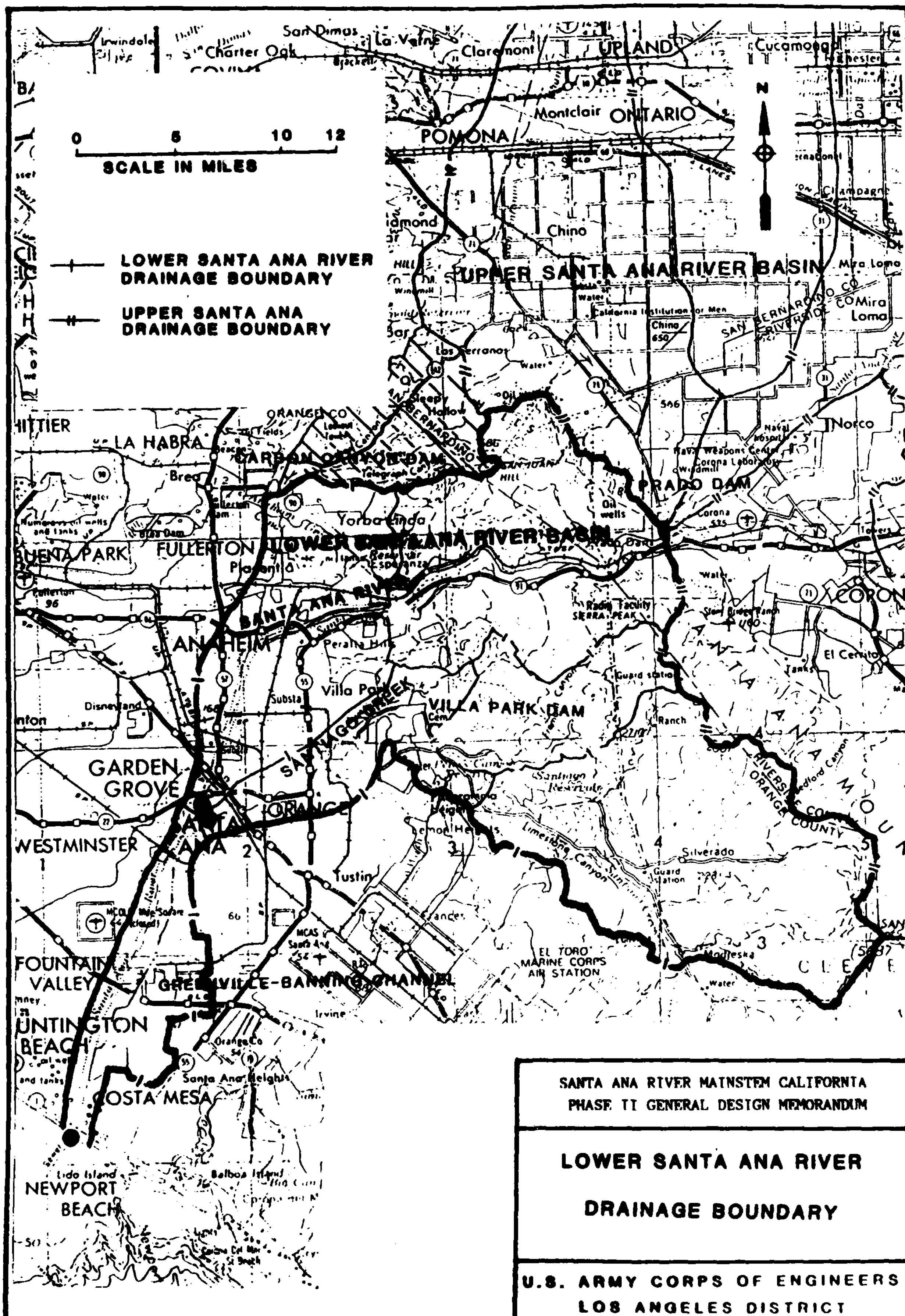
3-04 Interior flood control refers to drainage from areas protected from direct river flooding by levees or floodwalls. From the end of the canyon reach at Weir Canyon Road to 17th Street in Santa Ana, the project channel levee heights are generally 2-4 feet above the natural ground line. From 17th Street to the Pacific Ocean, the levee heights increase to about 10-15 feet above the natural ground line. Peak discharges and runoff volumes were determined for all interior drainage areas for the following three conditions:

a. Flood condition 1: 100-year local storm peak discharges in the side drains and contemporaneous local storm peak discharges in the river.

b. Flood condition 2: SPF local storm peak discharges in the side drains and contemporaneous local storm peak discharges in the river.

c. Flood condition 3: Contemporaneous general storm peak discharges in the side drains and design discharges in the river.

In general, condition 1 discharges (100-year) were used for side drain design. Condition 2 discharges (SPF) were used to identify residual flooded areas at the project channel. Hydraulic design and presentation of residual flooded areas are included in Chapter IV, Hydraulic Design.

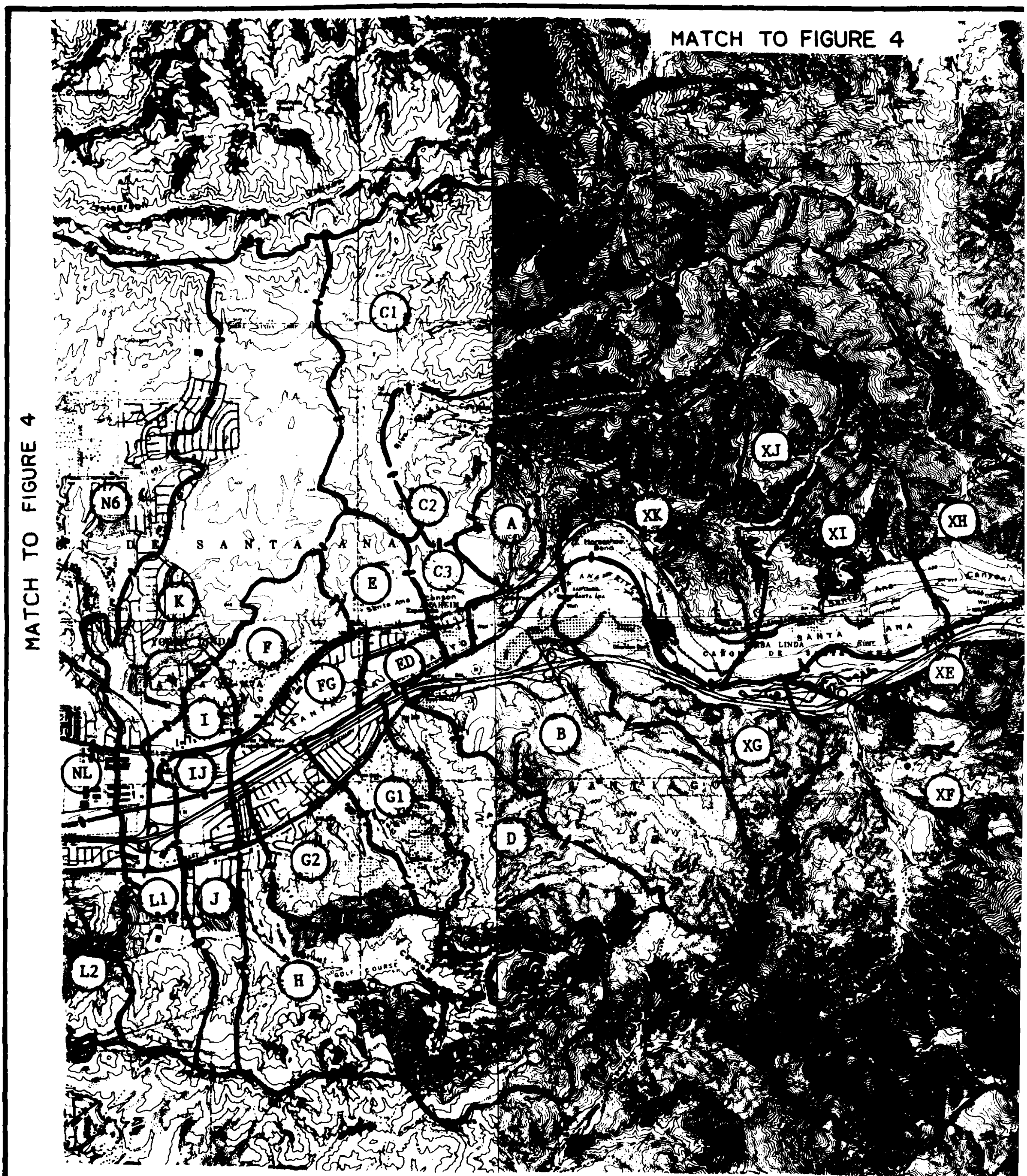


SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER
DRAINAGE BOUNDARY

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

CHAPTER 3 FIGURE 2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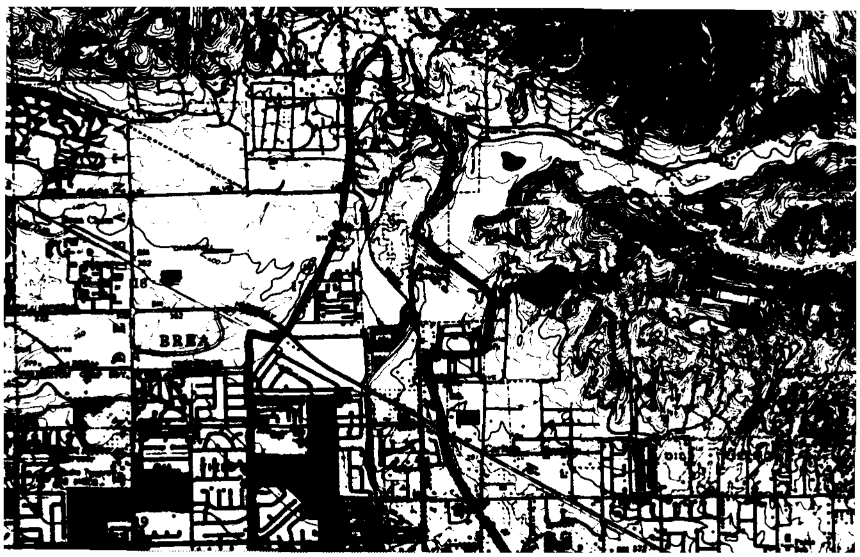
SANTA ANA
GOLF COURSE

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER
DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



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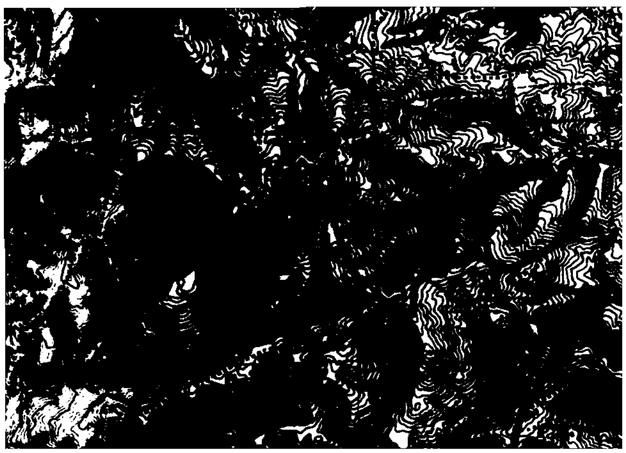


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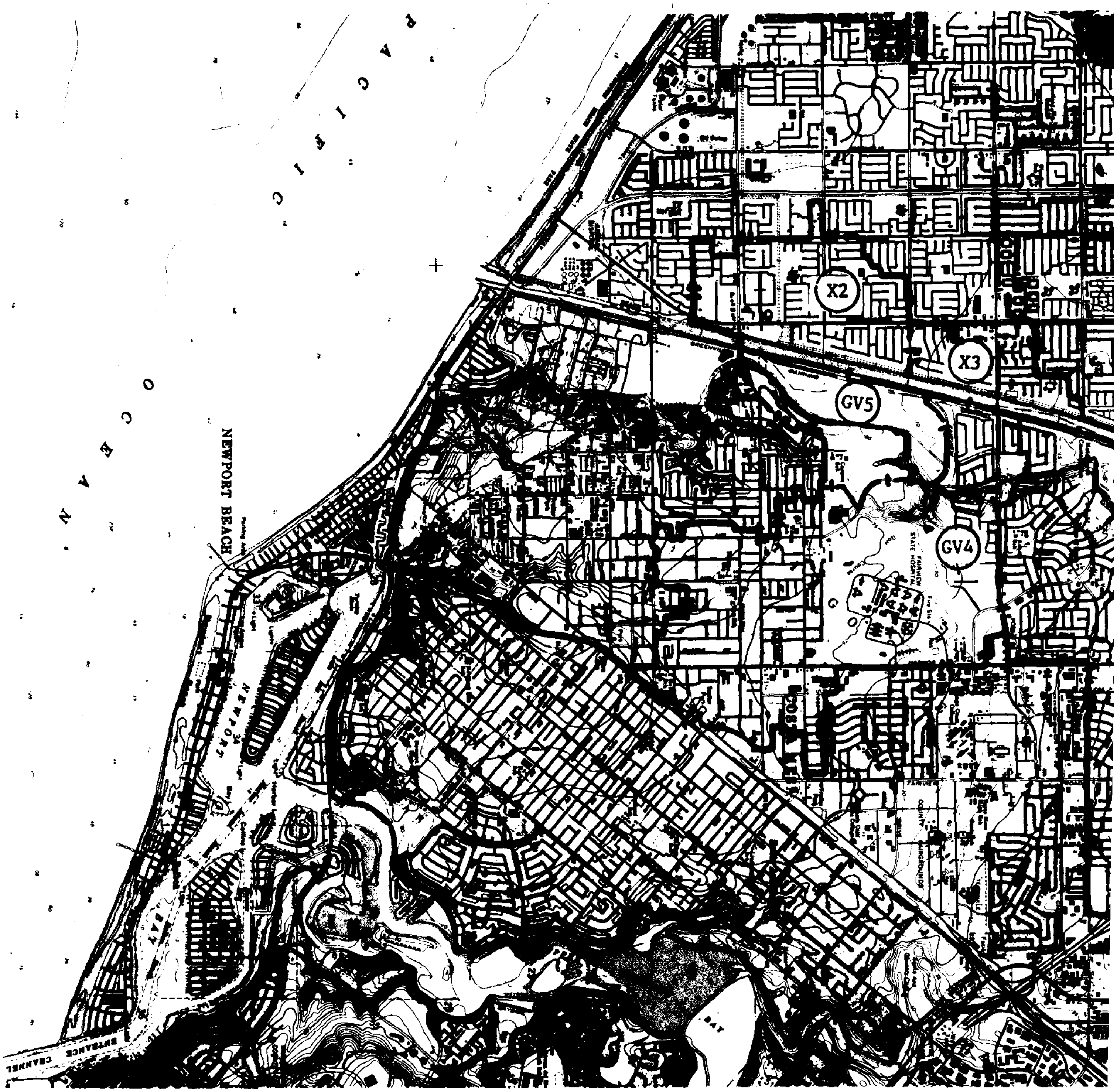
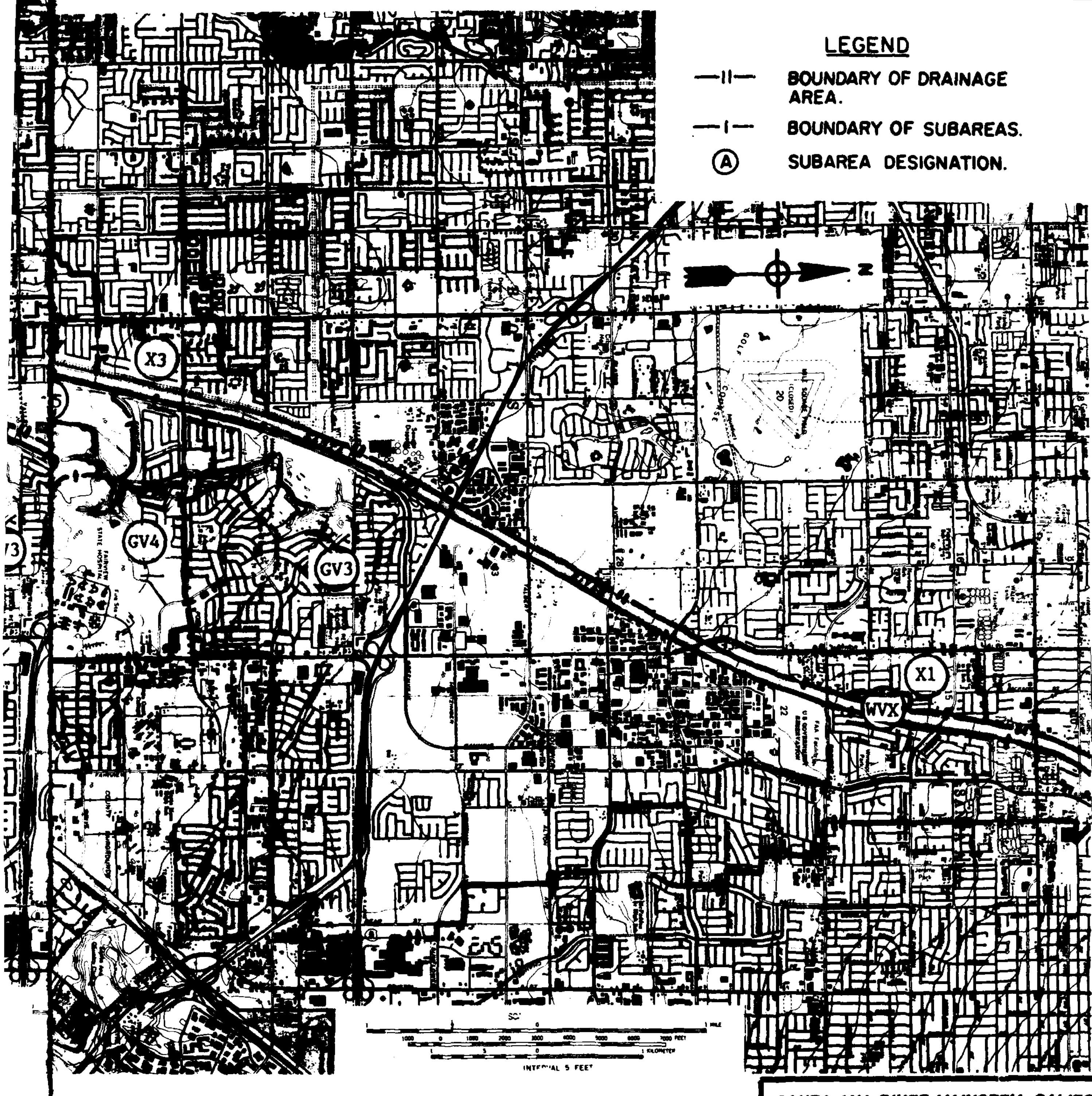
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER
DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT


PACIFIC
OCEAN
NEWPORT BEACH
NEWPORT
X2
X3
GV5
GV4
ENTRANCE CHANNEL
BAY



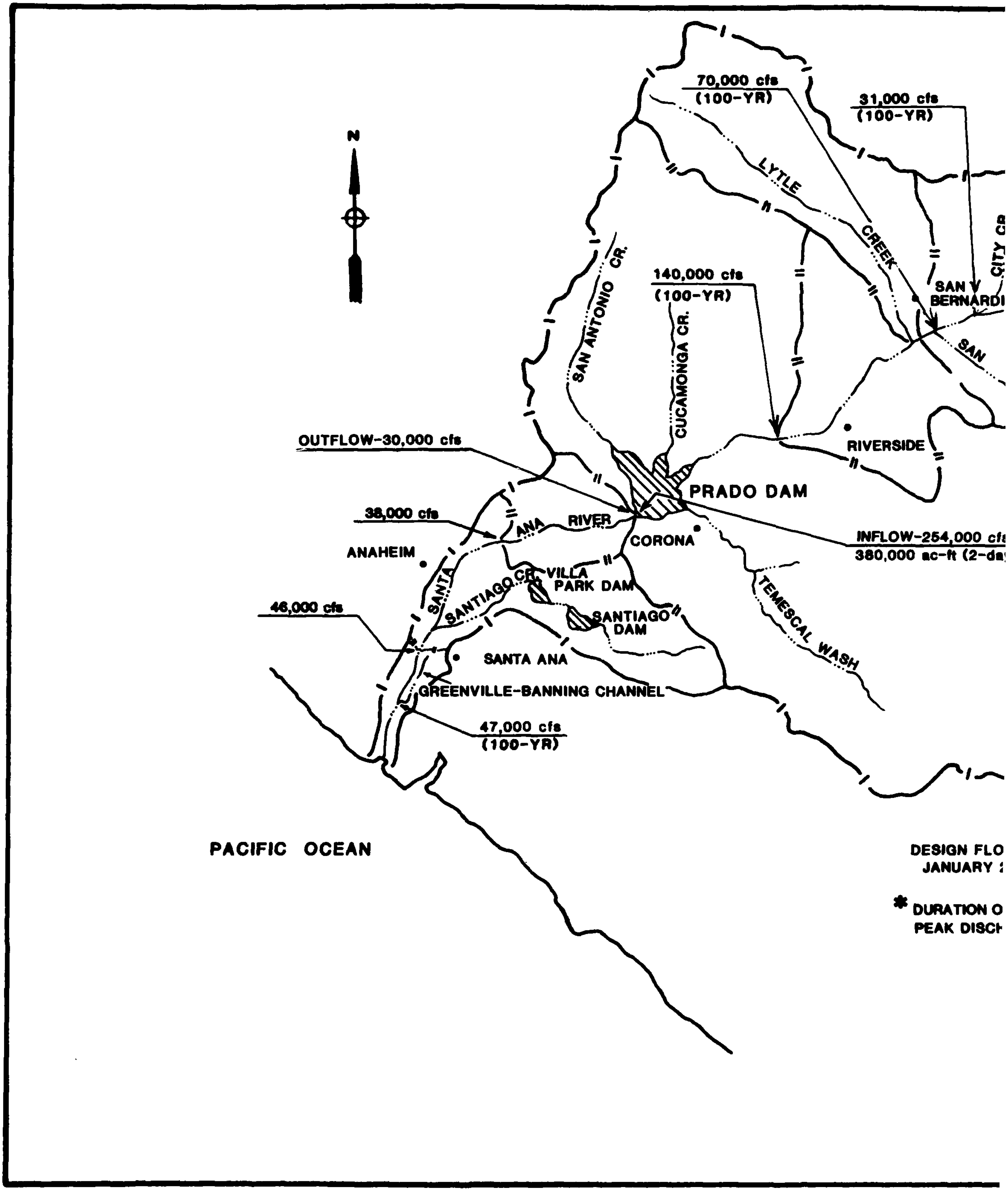
MATCH TO FIGURE 5

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

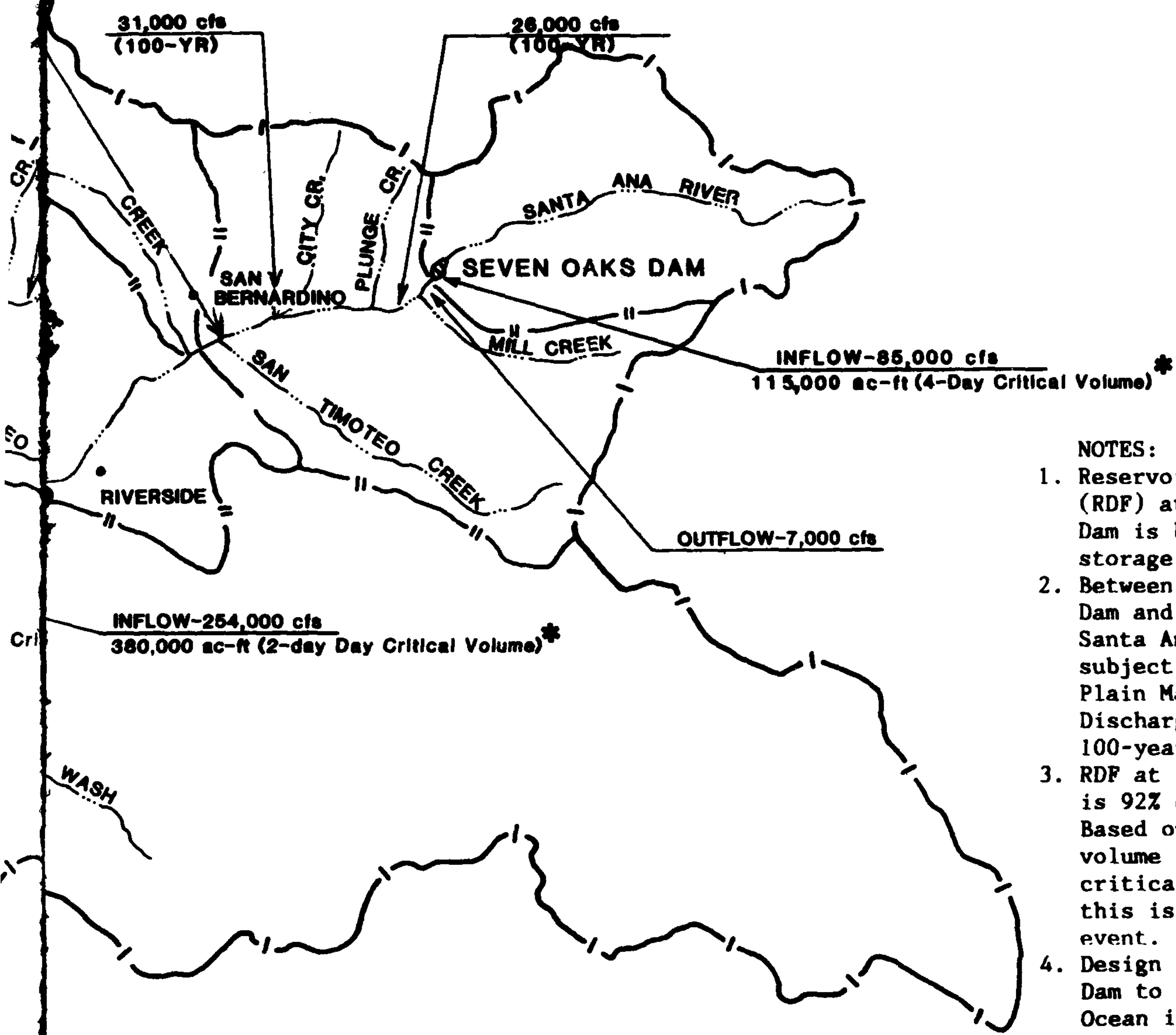
LOWER SANTA ANA RIVER
DRAINAGE AREA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE 6



N
70,000 cfs
(100-YR)
31,000 cfs
(100-YR)
LYTLE
CREEK
CITY CR
SAN
BERNARDI
SAN
SAN ANTONIO CR.
140,000 cfs
(100-YR)
CUCAMONGA CR.
RIVERSIDE
OUTFLOW-30,000 cfs
PRADO DAM
38,000 cfs
SANTA
ANA
RIVER
CORONA
INFLOW-254,000 cfs
380,000 ac-ft (2-da
ANAHEIM
SANTIAGO CR.
VILLA
PARK DAM
46,000 cfs
SANTIAGO
DAM
TEMESCAL WASH
SANTA ANA
GREENVILLE-BANNING CHANNEL
47,000 cfs
(100-YR)
PACIFIC OCEAN
DESIGN FLO
JANUARY
* DURATION O
PEAK DISCH



NOTES:

1. Reservoir Design Flood (RDF) at Seven Oaks Dam is based on NED storage.
2. Between Seven Oaks Dam and Prado, the Santa Ana River is subject to Flood Plain Management. Discharges are 100-year frequency.
3. RDF at Prado Dam is 92% of SPF. Based on 2+ day volume being the critical duration, this is a 190-year event.
4. Design flood from Prado Dam to the Pacific Ocean is a 190-year event.

DESIGN FLOOD BASED ON OCCURENCE OF JANUARY 21-24, 1943 GENERAL STORM.

* DURATION OF CRITICAL VOLUME IS THAT WHICH GENERATED PEAK DISCHARGE AND WATER SURFACE ELEVATION

SCALE IN MILES

5 0 5 10

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGN FLOOD PEAK DISCHARGES
SANTA ANA RIVER
FUTURE CONDITIONS
WITH RECOMMENDED PLAN

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE 7

2

IV. HYDRAULIC DESIGN

General

CRITERIA

4-01 The hydraulic design of the recommended improvements is based on criteria and procedures set forth in EM 1110-2-1601, Hydraulic Design of Flood Control Channels. Project drop structure design is based on the hydraulic model study recommendations prepared by Waterways Experiment Station, in Vicksburg, Mississippi. Freeboard selection incorporated design goals prescribed in ETL 1110-2-299, Overtopping of Flood Control Levees and Floodwalls. Riprap layer thickness determination is from ETL 1110-2-120, Additional Guidance for Riprap Channel Protection.

EXISTING CHANNEL

4-02 The existing Santa Ana River downstream from Prado Dam is a well defined channel that has been improved by local interests. Intermittent levees and bank protection have been provided along the river in the Santa Ana Canyon below Prado Dam. From Weir Canyon Road to River View Golf Course, the river is a trapezoidal levee section with revetted side slopes and soft bottom. Orange County Water District utilizes the sandy bottom of the channel to recharge the groundwater aquifer and the Orange County Flood Control District has built a series of drop structures to control bed scour. From the River View Golf Course to the Pacific Ocean, the river is a leveed section with concrete lined side slopes and earth bottom. In this reach, the channel invert has degraded, exposing the bridge pier foundation piles. In an effort to control bed degradation, channel stabilizers have been constructed. At the beach outlet, a sand plug forms in the dry periods and washes out during winter storms.

RECOMMENDED PROJECT

4-03 The 31 miles of the Lower Santa Ana River is divided into three reaches for hydraulic design purposes. The Canyon Reach extends from Prado Dam to Weir Canyon Road (sta. 1607+50 to sta. 1216+47). The Drop

Structure Reach extends from Weir Canyon Road to the concrete inlet just downstream from Santiago Creek (sta. 1218+90 to sta. 535+30). The Trapezoidal Ocean Reach extends from downstream of Santiago Creek to the river's outlet at the Pacific Ocean. The design discharges for the Lower Santa Ana River were given in table III-1. The recommended channel improvements, are shown on plates 4 through 53. Channel improvements are constrained by existing channel widths, drop structures, bridge deck levels, utilities along the river, existing rights-of-way, and urban development adjacent to the channel. The project channel will interface with the existing right-of-way lines and structural elements such as bridges and utilities to reduce relocation costs.

ALIGNMENT

4-04 In general, the alignment of the recommended channel will be along the existing channel. All rights-of-way for the proposed channel will be provided by local interests. Enhancement lands will be provided by the Federal Government. In order to clear property lines or existing structures, minor changes to the alignment presented in the Phase I GDM were made. All alignment revisions were coordinated with local interests. Generally, horizontal curves were used for deflection angles greater than 2 degrees and omitted for smaller deflection angles, which is accepted Los Angeles District practice. Deflection angles greater than 2 degrees were used without horizontal curves in this GDM. Adjustments will be corrected in the final plans. Because spiral curves are not used in trapezoidal cross sections spiral curves were omitted upstream and downstream from simple curves.

SEDIMENT TRANSPORT STUDY RESULTS

4-05 The hydraulic design of the Santa Ana River was analyzed using sediment loads to ensure that the project will function for design flows. The sedimentation analysis is discussed in detail in appendix C. The study established sediment load boundaries using the HEC-6 computer program developed by the Hydrologic Engineering Center at Davis, California. Study results were independently verified by Simons, Li and Associates, a sediment transport consulting firm. The analysis clearly indicates sediment deposition will occur in one soft bottom channel reach between drop structures and in the 5 miles upstream from the ocean outlet. The break in grade from steep to mild slope in the channel, 5 miles from the outlet, will change the flow condition from rapid to tranquil state resulting in a substantial sediment deposition. Water surface profiles with sediment deposition in the channel were used to establish wall heights.

HYDRAULIC MODEL STUDY

4-06 Model studies were required to design a series of drop structures for the soft bottom channel. Existing and recommended drop structures were tested at the Corps of Engineers Waterway Experiment Station to

ensure hydraulic adequacy of the project. The design objectives of the model testing program were to insure that the drop structures would provide good energy dissipation within the basin, minimize downstream scour, maximize the utilization of the existing drop structure configuration, minimize the cost of modifications, and provide for good performance for a range of discharges and tailwaters. It is necessary that the drop structures adequately dissipate energy not only for the channel design discharge (unit discharges of 125 to 165 ft^3/sec per foot width) but also for the maximum freeboard design discharge (unit discharges of 165 to 215 ft^3/sec per foot width). This is imperative, since failure of a drop structure could lead to failure of the levee resulting in catastrophic flooding in highly urbanized areas. The model study report was published as U.S. Army Engineer Waterways Experiment Station, Technical Report HL-88, dated January 1988. As a result of the model tests, the existing drop structures were modified to include a parabolic curved chute downstream from the crest, an additional basin length, two rows of baffle blocks, and a sloping end sill. Model tests of the recommended drop structures resulted in a stable hydraulic jump throughout the range of discharges and a reduction in velocities at the end sill. Saving the existing drop structures was made possible by successfully redesigning the stilling basin for larger unit discharges. The studies resulted in saving the existing 11 drop structures. Drop structure details are shown on plate 71.

DESIGN PROCEDURES

4-07 In general, the project was designed to utilize the available rights-of-way and to save the existing structures. Design efforts identified the most cost effective channel that could be constructed in a given reach. Sediment grade lines were established for the proposed channel, and water-surface profiles were computed. Minimum freeboard was provided to wall heights. A study was conducted to identify over-topping locations for floods exceeding the design discharge, and levees designed to safely pass excess flow over the levee(s). For the soft- bottom drop structure channel, 3 new drop structures and 21 stabilizers were added to maintain stable grades and control channel scour. As a minimum, side drains have been designed to carry 100-year flood frequency interior drainage runoff contemporaneous with local storm runoff in the Santa Ana River. The local storm river discharge contemporaneous with the interior runoff is about a 15-20 year event based on the discharge frequency curves for the Santa Ana River shown on plates 7-65 and 7-67, volume 7. Whenever feasible, storm drain capacity was upgraded to handle SPF design storm runoff from the drainage area. Flap gates have been provided, as required, to contain the design floodflows in the Santa Ana River.

TRANSITIONS

4-08 The channel was designed using straight-line transitions for the concrete channel. The wall flare for each wall (horizontal to longitudinal) conforms to the recommended 1:10 ratio for velocities up

to 15 feet per second and 1:15 ratio for velocities 15 to 30 feet per second. Transition losses were computed using loss coefficients of 0.10 for contraction and 0.20 for expansion (EM 1110-2-1601, paragraph 10, page 26).

BRIDGES

4-09 The procedures presented in EM 1110-2-1601 (pp. 15-19) were used to determine bridge losses. The design provides for 2 feet of debris loading on each side of each pier.

FREEBOARD

4-10 Freeboard is provided to ensure that the desired degree of protection will be provided and that levees will not fail for floodflows exceeding the design discharge. Minimum freeboard allowances were provided: 2 feet in reaches with rectangular cross sections and 2.5 feet in trapezoidal sections for concrete-lined channels; 2.5 feet for riprap-lined channels, and 3 feet for levees.

WATER SURFACE SUPERELEVATION AT CURVES

4-11 The superelevation required at curves was determined by methods outlined in EM 1110-2-1601. Since all superelevations were determined to be less than 0.5 feet, the normal channel freeboard was determined to be adequate.

ROUGHNESS COEFFICIENTS

4-12 Manning's roughness coefficients ("n" values) were used to estimate friction losses in calculating water surface profiles. The "n" values were verified by calculating the equivalent roughness (k value). Determination of roughness coefficients for each reach are discussed in the appropriate sections.

CONFLUENCE STRUCTURES

4-13 In confluence design, the wall height determination was based on the worst of two flow conditions: (1) design discharge in the main channel and the corresponding contemporaneous discharge in the side channel and (2) design discharge in the side channel and the corresponding contemporaneous discharge in the main channel.

RIPRAP LAYER THICKNESS DETERMINATION

4-14 Riprap layer thicknesses are based on criteria set forth in EM 1110-2-1601 and ETL 1110-2-120.

Santa Ana Canyon Reach

EXISTING CONDITIONS

4-15 The Santa Ana Canyon Reach, which extends from the Prado Dam outlet channel drop structure at station 1607+50 to approximately 700 feet upstream from the Weir Canyon Road bridge at station 1207+30, it has a length of approximately 7.4 miles and widths varying from 250 feet to over 2,000 feet. The channel is braided at a few locations and follows a winding course through the canyon with an average riverbed slope of 17 feet/mile. Most of the existing channel remains in natural condition except a section of about 3,500 feet of improved low flow channel around the southern edge of the Green River Golf Course. The improved low flow channel generally has a capacity of about 2,000 ft^3/s stabilized by growth of vegetation along the low flow channel banks. In high flow events the low flow channel is subject to erosion due to higher flow velocities. Several bank stabilization and flood control works exist in the canyon reach (table IV-2): The Lomas de Yorba-Sur levee on the right bank extending from station 1393+40 to station 1236+70, the Santa Ana Valley Irrigation (SAVI) levee on the left bank stretching from station 1279+90 to station 1216+40, the Green River Village levee on the left bank extending from station 1547+40 to the Atchison, Topeka and Santa Fe Railroad bridge abutment, and several reaches of CALTRANS Highway 91 embankment. The main channel capacity through the reach is restricted to 22,000 ft^3/s because of a geologic constricted narrow section extending from station 1431+00 to station 1424+00, with widths as narrow as 250 feet. A summary of existing flood control improvements in the canyon is presented in table IV-1.

EXISTING NON-FEDERAL CHANNEL IMPROVEMENTS

Lomas De Yorba-Sur Levee

4-16 On the right riverbank, the Lomas De Yorba-Sur levee extends from approximately 3,600 feet downstream from Coal Canyon road to approximately 3,000 feet upstream from the Weir Canyon Road bridge. Design of the levee was coordinated with the Corps of Engineers in 1981 to control the standard project flood discharge, without project, of 150,000 ft^3/s. The levee has a minimum freeboard of 3 feet above the standard project floodwater surface profile. With a graded side slope of 1 vertical on 2-1/2 horizontal, the riverside face of the levee is protected with a 33-inch thick layer of stone revetment. The revetment was designed to have a minimum toe depth of 6 feet below the existing invert and a minimum top elevation of one foot above the Intermediate Regional flood water surface profile of 48,000 ft^3/s.

Table IV-1. Santa Ana River, Santa Ana Canyon, Existing Flood C

River Reach				Flood Control I				
River Bank	No.	Start River Station	End River Station	Length (ft)	Type	Revetment Thickness (inches)	Toe Depth Below Thalweg (ft)*	Set From Flow Bank
Left	L-1	1602+10	1586+50	1560	1-ton RSP[1]	50	1 to 3.5	50 t
	L-2	1547+40	1515+10	3232	Levee	36-54	3.5 to 4	10 t
	L-3	1489+00	1440+80	4820	1-ton RSP	50	*(-14) to 0.5	10 t
	L-4	1406+00	1363+40	4260	RMCT[2]	Not known	*(-12) to 3	50 t
	L-5	1320+80	1281+20	3960	RMCT	Not known	(-3) to 4.5	10 t
	L-6	1268+40	1209+30	5910	Levee	36	6 to 12[3]	10 t
Right	R-1	1431+60	1426+40	520	Sheetpile	None	*Not known	0 to
	R-2	1398+90	1231+40	16750	Levee	33	(-2) to 5	100

[1] RSP-Rock Slope Protection
[2] RMCT-Road-Mixed Cement Treatment Soil
[3] Tied into river bedrock at several locations.

*Negative toe depths indicate that the toe is above the channel thalweg.

l Impr anta Ana Canyon, Existing Flood Control Improvements.

vement		Flood Control Improvement					
er)	D (	Revetment Thickness (inches)	Toe Depth Below Thalweg (ft)*	Set Back From Low Flow River Bank (ft)	Design Discharge (ft^3/s)	Protection Object	Name/Owner
0	N	50	1 to 3.5	50 to 200	Not known	Highway	CALTRANS
0	N	36-54	3.5 to 4	10 to 150	Not known	Houses	Green River Village Levee
0	N	50	*(-14) to 0.5	10 to 150	Not known	Highway	CALTRANS
0	N	Not known	*(-12) to 3	50 to 300	Not known	Highway	CALTRANS
0	N	Not known	(-3) to 4.5	10 to 400	Not known	Highway	CALTRANS
0		36	6 to 12[3]	10 to 600	48,000	Houses	Savi Ranch Levee
	N	None	*Not known	0 to 10	Not known	Railroad	AT&SF RR Co.
00		33	(-2) to 5	100 to 700	48,000	Houses	Lomas De Yorba Sur Levee

l thalweg.

2

Guidelines provided to the local sponsor consisted of the revetment design requirements using Corps' criteria and recommended toe depths. Since toe depth is site specific, the following depth of revetment were recommended: Where the set back between the low flow riverbank to the revetment is greater than 400 feet, the revetment should be extended to at least 5 feet below the adajacent streambed. The depths are considered adequate because severe bank erosion will probably occur mainly during long duration low flow releases from Prado Dam. The long duration should provide sufficient time to flood fight, and the low magnitude of the discharge will result in a water surface too low to flood the subject property even if the levee were to breach. Hence, after completion of the project, this levee would also serve as bank protection.

The SAVI Ranch Levee

4-17 The existing SAVI Ranch Levee, approximately 6,000 feet in length, starts at station 1279+90 where the existing ground elevation exceeds the design flood elevation and extends downstream to a point just upstream from the Weir Canyon bridge. Constructed on the left riverbank in 1980, the levee was designed to control against the Intermediate Regional flood with a peak discharge of 48,000 ft^3/sec. The levee has a minimum freeboard of 3 feet above the design flood water surface profile and a minimum levee top width of 20 feet. Both faces have a graded side slope of 1 vertical on 2 horizontal. A layer of 3 foot thick stone revetment was provided on the riverside face for bank protection. The toe of the revetment was set at a minimum of 5 feet below the estimated stable channel slope as defined in the "Project Report, Santa Ana River, Facility No. EO-1, 3,000 feet downstream from the proposed Weir Canyon Road" by the Orange County Flood Control District, dated September 1972.

4-18 Since the completion of the original SAVI Ranch Levee, an extension of approximately 600 feet downstream from the Weir Canyon bridge has been constructed by Orange County. Construction has been completed extending the existing SAVI Ranch Levee in both the upstream and downstream directions to tie into the Riverside Freeway embankments. The upstream and downstream extensions are approximately 2,000 and 2,500 feet in length, respectively. Another levee improvement being undertaken near the SAVI Ranch is to extend the existing stone revetment downward to at least 8 feet into the river or to bedrock for a section of approximately 370 feet in length located about 1,700 feet upstream from the Weir Canyon bridge. The improvement is for scour protection against long duration low flow that impinges the levee due to abrupt change of flow direction.

Green River Village

4-19 The Green River Village Levee extends upstream from the left abutment of the Atchison, Topeka and Santa Fe Railroad bridge for approximately 3,000 feet. The levee was built in two stages: the upstream section of approximately 1,600 feet was installed in 1985 to

protect the Green River club houses, and the downstream section which connects the upstream section into the railroad bridge abutment was completed in 1987. The levee revetment has a river face side slope of 1V on 2H with riprap thickness varying from 36 inches to 54 inches, and at the toe, a horizontal base having a minimum width of 20 feet and a thickness of 60 inches is tied into the riverbed armor layer. A minimum vertical distance of 20 feet is required from the top of riprap to the top of the horizontal toe base. CALTRANS 1/4-ton class rock materials were used for constructing slope protection, and CALTRANS 1-ton class for toe base.

Highway 91 Bank Protection

4-20 On the left riverbank, in order to protect the Riverside Freeway (Highway 91) against sustained low impinging flow, CALTRANS has constructed and upgraded four sections of channel for bank protection. Locations and design information for the sections are shown in table IV-2. Further coordinations with CALTRANS are necessary to insure the quality for bank protection especially for locations where no set back between the low flow river bank and the freeway is available.

Atchison, Topeka, and Santa Fe Railroad

4-21 On the right riverbank, at about station 14+00, a section of sheet pile was constructed by the AT&SF RR Co. to protect the railroad and embankment. Since the work was done as an emergency measure, construction plans are not available for review. Therefore, no conclusions can be made about the integrity of this feature. As this feature is located in a reach subject to impinging flow, further coordinations with the AT&SF will be required to determine the adequacy of the existing improvement.

RECOMMENDED IMPROVEMENT

4-22 Overflow analyses for the existing conditions indicate that the mobile home park behind the Green River Golf Course will be flooded when flow exceeds 22,000 ft^3/sec. To protect the mobile home park against the design flood of 33,500 cfs through the golf course, a levee extending from station 1515+10 to station 1490+00 is recommended. The upstream end of the levee will be tied into the AT&SF RR bridge abutment, and the downstream end to the Riverside Freeway embankment. The levee has a minimum 3-foot freeboard above the design flood water surface elevations and a 15-inch thick layer of grouted stone revetment protection on riverward side slope of 1 vertical on 2 horizontal. The toe of the grouted stone revetment will extend a vertical distance of 18 feet below the thalweg.

RIVER CONTROL LINE

4-23 The river control line in this reach was chosen to follow the natural river course through the canyon. The control line was established with coordinates for points of intersection, bearing, curve

data, and control stations along the river for calculating precise distance in documenting structure locations and in computing the water surface profile. Eighteen horizontal curves with radii varying from 350 feet to 4,000 feet, and deflection angles ranging from 17 degrees to 79 degrees were utilized in this meandering reach.

WATER SURFACE PROFILES

4-24 Water surface profiles were computed with the application of the computer program 723-X6-L202A, titled HEC-2, Water Surface Profiles. The Standard Step Method was used in the program to solve the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation. In routing the design flood through the canyon reach, values of Manning's coefficient of roughness "n" ranging from 0.025 to 0.0425 for the main channel and from 0.025 to 0.1 for the overbanks were applied to reflect channel conditions and land uses on riverbanks. Contraction coefficients were from 0.1 to 0.3, expansion coefficients from 0.3 to 0.5. This analysis was used to delineate the design flood boundaries and to evaluate the post project lands to be acquired for open space within the canyon area.

Drop Structure Reach

CHANNEL IMPROVEMENTS

4-25 The recommended channel in this reach extends from the earth bottom channel inlet just upstream from Weir Canyon Road bridge (sta. 1216+47) downstream approximately 12.9 miles to the concrete channel inlet just downstream of the confluence with Santiago Creek (sta. 535+80). The channel will be an earth bottom trapezoidal section, with side slopes consisting of riprap or grouted riprap placed on a slope of 1 vertical on 2 horizontal. The channel base width will range from 270 feet to 330 feet and will conform to the base width of the existing channel. The invert design slopes vary from 0.00168 to 0.00222. The channel design will incorporate the 11 existing drop structures, and add three new drop structures. A physical model analysis of the drop structures was conducted. To control general degradation of the streambed, a minimum of one invert stabilizer will be placed in each drop structure subreach, except for one short subreach upstream from the drop structure located at station 891+90.

4-26 The alignment of the channel will follow the alignment of the existing channel. A total of 16 horizontal curves will occur in this reach, with deflection angles ranging from a maximum of about 41 degrees to a minimum of 2 degrees. The radii of the horizontal curves will range from a maximum of 20,000 feet to a minimum of 1,000 feet. Horizontal curves with deflection angles less than 2 degrees were defined only with angle points about the centerline of the channel. There are six angle points in this reach. Spiral curves were not necessary upstream and downstream from simple curves because of stable subcritical flow conditions in a trapezoidal channel.

WATER SURFACE COMPUTATIONS

4-27 The water surface profile was calculated using the Los Angeles District's computer program "WASURO" for the design flood. Friction losses in the program are accounted for by the use of the Manning's roughness coefficient "n". An "n" value of 0.03 was used in the analysis for the design water surface profile and was based on several methods, which are discussed in a subsequent paragraph. Transition losses are accounted for in the program by the use of contraction and expansion coefficients. Contraction and expansion values of .1 and .2 were used, respectively. The water surface profile for levee height design was analyzed for two invert slope conditions in the channel. First, the profile was computed using the design invert slope for the entire reach. Second, the profile was recomputed using the design sediment invert slope from the sediment transport analysis (exhibit 1, appendix C) for a condition of channel aggradation at the design peak discharge. The results of the sediment analysis indicate that the design sediment slope was only necessary in the first drop structure reach just downstream from the inlet (sta. 1202+59 to sta. 1156+30). The flow state will be stable subcritical flow, with Froude Numbers less than 0.6. The hydraulic elements, plan, and profile are shown on plates 8 through 32.

ROUGHNESS COEFFICIENT

4-28 An important parameter in the water surface computations is the Manning "n" value. The "n" value was evaluated using several methods that account for the roughness due to the bed grain size and the bed form. The first method evaluated was the roughness height "k" value. Following guidelines in EM 1110-2-1601 and applying the sediment bed form results of plane bed/antidunes, a "k' value of 0.0033 was used. The corresponding Manning's roughness coefficient is 0.015. The second method was the U.S. Geological Survey procedure for sand bed streams in upper regime. This procedure involves developing a base "n" value from Limerinos' equation that relates "n" to the hydraulic radius and the particle size, and then adjusting the "n" by the Cowan's method presented in Open Channel Flow by V.T. Chow. The resulting "n" value was 0.017. The third method, (Alam and Kennedy) takes into account the bed form. The resulting "n" value was 0.016. The final method (Simons and Li) displays the range of "n" values for a given bed form and provides a suggested "n" value for sediment transport analysis. The suggested "n" value for plane bed is 0.022.

4-29 In addition to the bed "n" value, a composite "n" value for the channel was computed using equation 4 of HDC sheets 631-4 and 631-4/1 to account for the different bed and side-slope roughness (table IV-2). The "n" value for the side slope was derived from the roughness height "k" for the riprap and applying plate 4 of EM 1110-2-1601.

Table IV-2. "n" Value Results.

	Method	Bed "n"	Composite "n"
a.	Plate 4, EM 1601	0.015	0.018
b.	U.S.G.S.	0.017	0.020
c.	Alam & Kennedy	0.016	0.019
d.	Simons & Li	0.022	0.025

This table shows that the "n" value varies depending on the method used. Because of this variation in the "n" value and because the flow is in the upper regime of plane bed/antidunes, two "n" values were used to design the levees. A high "n" of 0.03 was applied for water surface computations and hence, the design of the top of levees. This "n" value is at the upper limit for bed forms in the plane bed/antidune range. It also represents a conservative approach in the levee design. A low "n" value of 0.02 was used for determining channel velocities and depths in the design of the riprap layer thickness. This "n" value represents a reasonable low value in the plane bed regime.

INLET STRUCTURE

4-30 The improved channel inlet would be a channel transition from the 800-foot-wide trapezoidal section at station 1216+47 to the 320-foot wide trapezoidal section at station 1208+21. The right bank protection would be set back into the existing bank. The left bank levee protection would tie directly into the exiting SAVI levee. The levee toe depth will be set 15-feet below the thalweg to counter against cross flows entering the inlet. In addition, the inlet protection will be grouted riprap. The "n" value in the hydraulic analysis was increased to 0.04, based on Cowan's method, to account for both the change in the cross section and the increase in the vegetation allowance in this reach.

DROP STRUCTURES

4-31 A total of 14 drop structures will be utilized in this reach to maintain stable subcritical flow. Eleven drop structures exist on the river and will be modified as a result of the physical model study (see pl. 71) to convey the design discharge. Two drop structures will be added upstream from Imperial Highway bridge, and one will be added just upstream from the confluence with Santiago Creek. The levees at the drop structures will be grouted riprap. The toe of the levee will be 5 feet below the design invert on the upstream side and 15 feet below design invert on the downstream side. The 15 feet of toe depth is based on the San Gabriel River drop structure and levee design, which have

functioned successfully with design flood events, and the local scour trend observed in the model study. The 15-foot toe depth will extend 100 feet downstream from the drop structure. From this point, the levee toe will be sloped upward to meet with the general levee toe design from the downstream location, which is discussed in the subsequent riprap design paragraph. Table IV-3 presents the location and drop height (crest to end sill) for each drop structure.

STABILIZERS

4-32 The sediment transport analysis indicated that if the sediment inflow into the improved channel reach was significantly reduced, the bed slope upstream from drop structures would flatten to nearly a horizontal slope and hence, general degradation of the channel. To limit channel degradation, a minimum of one stabilizer will be placed upstream from each drop structure, except for a short 2,200-foot-long subreach upstream from the drop structure at station 891+90. The number of stabilizers in each drop structure subreach (table IV-4) was determined by limiting general degradation to 5 feet maximum between structures. The design of the stabilizer will be patterned after plate 39 of EM 1110-2-1601. This stabilizer design has been modified by adding dump stone on the downstream side to counter local scour. The levee protection at the stabilizers will be grouted riprap. The levee toe depth will be 5 feet on the upstream side and 10 feet on the downstream side. The 10-foot levee toe depth will extend 100 feet downstream from the structure. From this point, the levee toe will be sloped upward to meet with the general levee toe design.

CONFLUENCE STRUCTURES

4-33 Two major and several minor tributaries enter the Santa Ana River in this reach. The major confluences are the Carbon Canyon Diversion Channel (E02) at station 846+25 and Santiago Creek (E08) at station 564+00. The minor confluences are local side drains that enter into the river. A discussion of these drains can be found under Interior Drainage.

4-34 The existing E02 is enclosed by channels and levees with the lowest top of levee elevation 219.8 feet NGVD. The design water surface at the confluence, using the design discharge of 38,000 ft^3/s on the mainstem with the contemporaneous discharge on E02 of 2,000 ft^3/s is elevation 218.0 feet NGVD. Because the water surface on the mainstem is lower than the top of levee on E02, no modification will be required on E02. The subcritical flow condition on the both the mainstem and E02 will require a confluence structure that simply joins together at the natural angle.

4-35 The Santiago Creek confluence will be improved in conjunction with the proposed Santiago Creek Project. The water surface profile at the confluence was computed using the design discharge on the mainstem of 42,000 ft^3/s with the contemporaneous discharge on Santiago Creek of 4,000 ft^3/s. Again, because of the subcritical flow conditions on both the mainstem and tributary, the confluence structure will simply join

together at the natural angle. The mainstem channel invert downstream from the confluence was lowered by about 5 feet from the design invert shown in the Phase I GDM to improve the backwater conditions upstream into Santiago Creek. This lowering of the channel necessitated the addition of a drop structure upstream from the confluence to meet the existing mainstem invert grade line.

Table IV-3. Drop Structure and Stabilizer Location.

Type of Structure	Station Location	Drop Height (ft)
Drop Structure	1203+12	4.54
Stabilizer	1179+50	
Drop Structure	1156+30 (new)	7.04
Stabilizer	1131+30	
Drop Structure	1106+30 (new)	7.07
Stabilizer	1087+65	
Stabilizer	1069+00	
Stabilizer	1050+40	
Drop Structure	1030+70	5.25
Stabilizer	1013+50	
Stabilizer	995+70	
Drop Structure	977+90	5.13
Stabilizer	956+90	
Stabilizer	935+85	
Drop Structure	914+85	6.07
Drop Structure	891+90	4.11
Stabilizer	876+77	
Stabilizer	862+15	
Drop Structure	844+40	9.16
Stabilizer	828+30	
Drop Structure	811+40	9.16
Stabilizer	794+90	
Stabilizer	778+40	
Stabilizer	761+90	
Drop Structure	745+40	9.15
Stabilizer	727+00	
Stabilizer	707+00	
Drop Structure	689+85	7.27
Stabilizer	667+00	
Drop Structure	644+95	7.50
Stabilizer	622+50	
Drop Structure	601+25	6.47
Stabilizer	582+00	
Drop Structure	571+50 (new)	6.70
Stabilizer	558+00	

BRIDGES

4-36 A total of 19 bridges exist in this reach with no proposed new bridges (table IV-4). The hydraulic analysis, using 4 feet of debris on each pier, indicates Class A flow (subcritical) at all the bridges. In addition, local scour around the bridge piers was analyzed at each bridge using equation 9.16 of Sediment Transport Technology. At the bridges where the predicted local scour was deeper than the bridge pier footing, pier nose scour protection will be added to the upstream end of each pier.

Table IV-4. Pertinent Bridge Data.
(With Project)

Bridge	Station	Number of Piers	Local Pier Scour (ft)1/	Depth of Pier Nose Footing Below Invert (ft)	Type of Re-construction
Weir Canyon Rd.	1207+29	3	12.4	9.2	PNSP2/
Imperial Hwy.	1065+60	3	12.3	6.1	PNSP
Lakeview Ave.	983+48	5	11.4	4.5	PNSP
Riverside Fwy	926+28	8	11.0	3.4*	PNSP
Tustin Ave.	918+30	6	11.1	4.7	PNSP
AT & SF RR.	897+80	5	15.0	4.7	PNSP
Glassel St.	865+75	6	11.0	6.0	PNSP
Lincoln Ave	821+50	5	11.8	3.9	PNSP
Ball Road	749+30	5	12.2	4.9	PNSP
SPT CO RR	733+23	5	12.2	Not Known	Modify Rt. Abut
Katella Ave	708+92	7	12.2	2.0	Rebuild Bridge
AT & SF RR	693+40	3	12.2	0.3*	PNSP
Orange Fwy	682+20	5	12.8	9.0	PNSP
Orangewood Ave	668+85	6	11.8	3.8*	Rebuild Bridge
Chapman Ave	638+71	4	12.7	7.7	PNSP
Santa Ana Fwy	625+40	5	12.2	6.8*	Modify Piers
S.P. R.R.	624+40	3	15.2	Not Known	PNSP
Garden Grove Fwy	603+17	5	13.2	8.2*	Modify Piers
Garden Grove Bd	582+91	7	12.4	3.7*	Modify Piers

1/ Four feet of debris added to pier, except for piers 6 feet wide or more.

2/ Pier Nose Scour Protection.

* No pier nose at this location footing depth below invert.

RIPRAP DESIGN

4-37 The riprap was designed using the hydraulic parameters of average velocity and average depth computed by the "WASURO" computer program using a low "n' value of 0.02. This "n" value represents the approximate lower limit of "n" values estimated using the methods described in the paragraph 4-01. The procedure used for determining the appropriate riprap layer thickness was:

a. For stone with specific weight of 165 lbs/ft^3 and dry placement, a trial riprap layer thickness was selected from ETL 1110-2-120. The corresponding D50 maximum and minimum was computed using plate 30 of EM 1110-2-1601.

b. The local boundary shear was computed using equation 32 of EM 1110-2-1601 with D50 maximum, average velocity, and average depth. The local boundary shear was multiplied either by the non-uniform flow factor of 1.5 in straight reaches or by the channel bend factor from plates 33 and 34 of EM 1110-2-1601. In either case, the minimum factor is 1.5.

c. The riprap design shear was computed using equations 33 and 34 of EM 1110-2-1601 with D50 minimum, angle of repose of 45 degrees (see Geotechnical study for the use of this value), and 1 vertical on 2 horizontal side slopes.

d. The local boundary shear was compared with the design shear. If local shear was greater than design shear, steps a through d were repeated with a larger riprap layer thickness until the local shear was less than the design shear.

4-38 The result of this analysis indicates that the minimum required riprap layer thickness varies from a minimum of 12 to a maximum of 54 inches. In the channel reaches that require riprap 36 inches or greater, the levees were lined with a 15-inch layer of grouted riprap. The grouted riprap was determined to be more economical than riprap layers equal to or greater than 36 inches.

4-39 Revetment toe protection is in general accordance with Method A, on plate 37 of EM 1110-2-1601. The levee toe depth will extend a minimum of 5 feet below the design invert just upstream from a hardpoint such as a drop structure or stabilizer. Upstream from these hardpoints, the levee toe grade line was extended at one-half the design invert slope until it merges with the toe design of the next upstream hardpoint. The toe depth was designed based on the sediment transport analysis. From that analysis, the toe depth was increased to a constant 10 feet below design invert in only the first drop structure subreach downstream from Weir Canyon Road.

FREEBOARD

4-40 The freeboard design was a two-step process. First, the minimum freeboard for this reach was determined. Then, the locations for initial overtopping of the channel at least hazardous overbank areas for floods exceeding the channel capacity were determined. The objectives were to provide adequate levee designs such that flows that overtop levees do not produce catastrophic failures of the channel system and to minimize the impact on overbank facilities.

Minimum Freeboard

4-41 The minimum recommended freeboard is based on guidance provided in EM 1110-2-1601 and unpublished guidance provided by Office of the Chief of Engineers. The riprap trapezoidal channel in the drop structure reach is set below ground except for some reaches where the channel levees extend above ground a few feet. The general minimum freeboard allowance for this type of channel is 2.5 feet. The only major factor that was judged to affect this freeboard value was the changed conveyance due to bed forms and sedimentation. However, since the "n" value was set conservatively high due to bed forms and the effect of sedimentation in the channel was taken into account, the 2.5 feet of freeboard was judged to be adequate, with no increase necessary. Other factors considered were found to be either insignificant or not applicable to this reach. These factors included dynamic surges and waves, wind and boat generated waves, superelevation, ice, debris, local anomalies, transverse slope due to side weirs, and profile instabilities associated with braids and meanders. Consequently, the 2.5 feet minimum freeboard was adopted for the entire drop-structure reach.

OVERFLOW DESIGN

4-42 The selection and design of the levee locations for flow overtopping the channel was based on ETL 1110-2-299. Overflow levee sections were identified using the following steps:

a. Freeboard was set at a minimum of 3 feet for the entire reach.

b. The channel capacity was calculated using the "WASURO" program.

c. Discharges above the channel capacity were executed to determine the levee location of initial overtopping.

d. Freeboard was reduced to the minimum 2.5 feet at selected levee locations adjacent to least hazardous overbanks areas to initiate initial overtopping.

e. The "WASURO" program was rerun using a side overflow weir option to determine the split flow quantities. The length of the overflow weir was determined by a trial and error procedure taking into account the quantity of flow needed to exit the channel, and the channel capacity upstream and downstream from each side weir. Local side drain inflow was also taken in account in the analysis. The overflow weir coefficient was 2.65, which represents the coefficient for a broad-crested weir presented in King's Handbook. Table IV-5 presents the location of initial overtopping levees and the discharge quantities.

4-43 Flows over the levee at these locations will enter into overbank areas consisting of parks, freeway buffer zones, ground water basins, and parking lots. The backside to the overflow levees will consist of 12-inch grouted riprap to prevent erosion through the levee.

Table IV-5. Design Overflow Levees.

Station Upstream	Station Downstream	Overflow Levee	Channel Capacity Upstream (ft^3/sec)	Discharge Over Sideweir (ft^3/sec)	Downstream Remaining Discharge (ft^3/sec)
1202+50	1031+70	both		1/	56,000
1000+00	986+00	right	57,700	700	57,000
941+00	928+00	right	57,700	1,700	56,000
844+00	822+00	both	63,000	3,000	60,000
733+00	710+00	both	60,000	3,800	56,200
682+00	670+00	right	60,000	1,500	58,500

1/ Initial overtopping reach downstream from Prado Dam for flows exceeding 56,000 ft^3/sec.

Trapezoidal Ocean Reach

PROPOSED PROJECT

4-44 The trapezoidal ocean reach extends from station 535+30 to the outlet at the Pacific Ocean. The channel design will be a concrete trapezoidal section with 2H:1V side slopes and base widths ranging from 160 feet to 180 feet downstream from station 535+30 (300 feet upstream from 17th Street) to station 283+00 (600 feet downstream from Talbert Avenue). A 500-foot-long transition changes the trapezoidal channel

to a rectangular concrete channel. Base widths from station 273+00 (about 1,000 feet upstream from the San Diego Freeway) to station 156+82 (1,500 feet downstream from Adams Avenue) range from 246 feet to 365 feet. To prevent scour, a cutoff wall and dumped stone will be provided at the downstream end of the concrete channel (sta. 150+32). A 650-foot-long transition changes the rectangular channel to a soft-bottom trapezoidal channel.

4-45 The channel will be earth-bottom with a trapezoidal cross section. The channel will have riprap protected 2H:1V sideslopes from station 150+32 to the ocean with base widths ranging from 365 feet to 450 feet. The riprap side slope protection will extend from 10 to 12 feet below the design invert. A dumped stone grade stabilizer at the ocean outlet (sta. 13+00) will be provided to prevent headcutting. The channel will be entrenched from the inlet (sta. 535+30) to about station 380+00 (downstream from Edinger Avenue) and levees downstream to the ocean.

4-46 The invert slopes in the trapezoidal ocean reach vary from 0.0100 at the inlet to 0.00066 between stations 156+82 and 187+50 and will produce design velocities varying from 25 ft/sec to 8 ft/sec. Flow depths vary from 8 feet to 18 feet. The proposed channel transitions from a 250-foot wide rectangular cross section to a 365-foot wide rectangular section between stations 156+82 and 150+32. For the without-sediment condition this transition acts as a roughness control transition where rapid flow is transformed into tranquil flow without an abrupt hydraulic jump. However, the after-jump water surface elevation is approximately 10 feet lower than the with-sediment water surface elevation. For the with-sediment condition the hydraulic jump moves upstream from Talbert Avenue (a distance of approximately 14,000 feet). The two situations, with-sediment and without-sediment, are considered to be the extremes expected. The wall heights were designed for the worst-case, or the with-sediment condition.

4-47 The existing Talbert Channel outlet to the ocean will be relocated approximately 1,000 feet upcoast (northwest) from the mouth of Santa Ana River. The local sponsor is proceeding with the channel design and the consultant firm of Simons, Li and Associates has been retained by OCEMA (Orange County Environmental Management Agency) to prepare the plans. The plan features will consist of a outlet jetties, and entrenched trapezoidal channel, and a new bridge at Pacific Coast Highway. The channel is designed for a 6,300 cfs discharge and 4.2 feet MHHW, tide level at the ocean.

ALIGNMENT

4-48 A total of 5 horizontal curves will occur in the Ocean Reach alignment with deflection angles ranging from a maximum of about 26.5 degrees to a minimum of less than 10 degrees. The radii of curves will range from a maximum of 20,000 feet to a minimum of 2,730 feet. In addition, there will be 5 angle points each less than 1.5 degrees.

SEDIMENT TRANSPORT STUDY RESULTS

4-49 The HEC-6 computer program was used to identify the invert slopes resulting from possible sediment degradation and deposition. The study determined that the concrete channel from the inlet at station 535+30 downstream to approximately to station 278+00 would be free of sediment deposition since velocities are high enough to carry the sediment load. The worst case sediment condition shows sediment deposition starting at station 290+00 and increasing in depth to about 7 feet at station 187+50, (1,500 feet upstream from Adams Avenue) and then decreasing in depth to 1.5 feet at the ocean outlet. The worst case sediment slopes throughout this reach (sta. 278+00 to the ocean) vary from .001476 to .00035. The with-sediment water surface was computed using the worst case sediment slopes and a Manning's roughness coefficient of 0.030. To minimize maintenance of the concrete channel due to erosion by sediment abrasion, an additional 2 inches of concrete wearing surface has been provided in the low flow channel between stations 535+30 and 156+82.

WATER SURFACE COMPUTATIONS

4-50 The water surface profiles were computed by the reach method using the Manning's Formula. The computer program "WASURO" to compute friction losses was used to perform these computations. Manning's "n" value of 0.014 was used to compute flow depths in the concrete channel. The use of a Manning's "n" value of 0.014 allows for an increase in channel roughness which results from typical channel weathering. According to plate 4 of EM 1110-2-1601, an "n" value of 0.014 corresponds to a suraface roughness "k" of about 0.002 which is within the 0.0015 to 0.0100 range shown in table 8-1 of Chow's "Open Channel Hydraulics", and falls below the upper limit of "k" recommended in the EM. It is recognized that the guidelines on channel roughness presented by Chow are for general use and that the final judgment would be based on local conditions. The Los Angeles District Office in 1966, with the assistance of the U.S. Geological Survey, conducted a prototype test to determine the channel roughness on the Tujunga Wash Channel, a rectangular concrete channel constructed in 1952. The prototype test "n" values determined ranged from 0.0114 to 0.012. Based on plate 4 of the EM, these "n" values would correspond to apparent roughness "k" values of 0.0006 to 0.0010 feet. Therefore, the use of "k" equal to 0.002 for smoother concrete is appropriate. In the portion of the Ocean Reach where sediment is deposited (sta. 8+30 to sta. 278+00) a high "n" value of 0.030 was used for water surface computations and hence the design of the tops of levees. A low "n" value of 0.020 was used for determination of depths and velocities in the design of riprap layer thickness. For a discussion of the determination of n = 0.030 see paragraphs 4-28 to 4-29.

WATER SURFACE PROFILE

4-51 Eighteen thousand feet upstream from the ocean outlet, the invert grade breaks from steep to mild slope. The grade break will change flows from rapid to tranquil state in a form of a hydraulic jump. The profiles were computed with and without the worst case sediment deposit to establish the sensitivity of the jump location to sedimentation. The results of this analysis indicate that the location of the jump is subject to the amount of sediment deposit in the outlet channel. Water surface profiles were computed with and without the worst case sediment deposit to locate the upstream migration of the hydraulic jump and to identify the maximum water surface profile for wall heights. To locate the jump, water surface computations were made from upstream and downstream control points. The hydraulic jump will have a Froude number of 1.15. Based upon EM 1110-2-1601 this is classified as a smooth undular jump with a surface wave. The highest expected water surface is based on the hydraulic jump located at station 283+00. The jump will have a 3.4 foot rise in water surface increasing the depth from 11.3 to 14.7 feet. Tail water depth in the channel will be 14.7 feet. Using design procedures outlined on plate 47 in EM 1110-2-1601, a 3.9 foot wave height was computed. Undular waves will be dissipated by boundary friction and an 18.1 foot flow depth at the San Diego Freeway bridge (pl. 44). (To contain wave action in the channel, 5 feet of freeboard was provided.) The depths in the channel will range from 8 to 18 feet and the velocities vary from 9 to 25 ft/s. The design water surface profile, with the worst case sediment deposit in the channel is summarized in the hydraulic element tables shown on the plan and profile plates, sheets 4 through 53.

BRIDGES

4-52 All of the bridges in the trapezoidal ocean reach upstream from the jump at station 283+00 have "Class B" flow condition, with a hydraulic jump forming upstream from each bridge. Downstream from the jump, the bridges are "Class A" flow condition. Most of the bridges have a minimum of 2 feet of freeboard. The bridges that do not meet this requirement, i.e., Adams Avenue, are recommended to be modified. The Adams Avenue structure has been hydraulically analyzed and judged to be able to withstand the design pressure flow condition.

FREEBOARD

4-53 A freeboard study conducted from Prado Dam to the inlet of the trapezoidal ocean reach determined that a maximum discharge of 65,000 ft^3/s will reach the inlet. Local inflow will increase the discharge to 71,300 ft^3/s at the ocean outlet. No least hazardous overtopping location was identified between the inlet of the trapezoidal ocean reach and the ocean outlet. The freeboard analysis indicates that the design channel with the minimum of 2.5 to 3 feet of freeboard could carry the 65,000 ft^3/s from the inlet at station 535+30 to about station 290+00. Downstream from station 290+00, freeboard was increased

to as much as 5 feet above the minimum 3 feet to convey the maximum expected discharge to the ocean. The Adams Avenue and Hamilton-Victoria Avenue bridges, which will remain in place, have 1.0 feet and 1.5 feet of freeboard respectively for the design discharge of 46,000 ft^3/s. Should the maximum discharge of 65,500 ft^3/s occur they will undergo pressure flow. The freeboard upstream of the bridges was adjusted so that the channel would contain this discharge.

INLET STRUCTURE

4-54 The inlet structure, located downstream of River View Golf Course (sta. 535+30) will consist of a 1,000-foot-long trapezoidal concrete chute with a slope of 0.0100. The bottom width will vary from 330 feet at the upstream end (sta. 535+80) to 180 feet at the downstream end (sta. 525+30). In order to reduce approach velocities, thereby reducing scour in the soft bottom channel, vertical concrete wing walls will be provided upstream from the inlet. To further reduce chance of scour, a 5-foot-deep cutoff wall will be provided. Velocities are therefore kept below 12 ft/s upstream from the inlet but increase to almost 25 ft/s downstream from the inlet.

RIPRAP

4-55 In the ocean reach where the section is trapezoidal (sta. 8+30 to sta. 150+32) and riprap is required on the side slopes. The thickness was determined as described in paragraphs 4-37 and 4-38. However, in this reach riprap below elevation 2.7 MHHW (mean higher high water) will require underwater placement and layer thicknesses were determined using incl 2, page 3, ETL 1110-2-120. Downstream of station 13+40 the channel has been designed to coastal criteria (see sheet 67 for jetty design).

GREENVILLE-BANNING CONFLUENCE

4-56 The Greenville-Banning confluence is located in the ocean reach. Both the Greenville-Banning Channel and the Santa Ana River at the confluence will be in tranquil flow condition. In the confluence design the wall height determination was based on the worse of two flow conditions:

a. Peak discharge in the main channel and the corresponding contemporaneous discharge in the side channel.

b. Peak design discharge in the side channel and the corresponding contemporaneous discharge in the main channel.

The confluence was analyzed using the above flow combinations. The results indicate that the peak in the mainstem determines the Greenville-Banning water surface design for a distance of 3,600 feet upstream from the confluence. Upstream from this point the peak in Greenville-Banning determines the water surface.

Greenville-Banning Channel

GENERAL

4-57 The existing Greenville-Banning Channel discharges directly into the ocean. Under the recommended plan this channel will discharge into the Santa Ana River just downstream from Hamilton-Victoria Avenue. The channel will be improved by the Corps for a distance of 16,800 feet upstream from the confluence with the mainstem channel.

EXISTING CHANNEL

4-58 For the reach extending upstream from the ocean outlet approximately 24,000 feet, the existing Greenville-Banning Channel is a concrete trapezoidal channel with base widths varying from 80 feet to 40.5 feet and side slopes of 1.5 horizontal to 1 vertical.

CHANNEL IMPROVEMENTS

4-59 The recommended confluence of the Greenville-Banning Channel with the Santa Ana River is located downstream from the Hamilton-Victoria bridge between Santa Ana River stations 76+40 and 72+90. At station 76+40 the Santa Ana River Channel has a base width of 410 feet with a soft bottom and riprap side slopes. The Greenville-Banning Channel enters parallel to the Santa Ana River as a 60-foot wide concrete rectangular channel. Station 9+30 is the beginning downstream station for the Greenville-Banning Channel. From station 9+30 to station 145+00 the recommended channel is a rectangular concrete section with base widths varying from 60 feet to 50 feet. Between station 145+00 and 147+00 the recommended channel transitions from rectangular concrete to trapezoidal concrete with 1.5 horizontal to 1 vertical side slopes. From station 147+00 to station 177+00 the recommended channel is trapezoidal with a base width varying from 50 feet to 24 feet. Recommended invert slopes vary from 0.0535 to 0.000415.

ALIGNMENT

4-60 In general, the alignment of the recommended Greenville-Banning Channel will follow the existing channel and approximately parallel the Santa Ana River mainstem. The alignment is generally the same as shown in the 1980 Phase I GDM. The centerline has 6 angle points ranging from a maximum of less than 4 degrees to a minimum of more than 1 degree and two horizontal curves with deflection angles ranging from more than 9 degrees to less than 5 degrees and radii of curvature of 18,000 feet and 20,000.

WATER SURFACE PROFILES

4-61 The water surface profiles were determined by using the LAD computer program "WASURO". The water surface in Greenville-Banning Channel is controlled by backwater in the Santa Ana River. It was assumed that there would be minor sediment deposition at the downstream

end of the channel. An "n" value of 0.024 was used for this short reach of sediment deposition. This value was calculated using WES Hydraulic Design Chart 631-4 titled "Open Channel Flow Composite Roughness" effective Manning's "n", and assuming an n = 0.030 for the bottom sediment and n = 0.014 for the concrete channel walls. An "n" value of 0.014 was used for the concrete channel. The "n" values were verified from "k" value determinations as described in paragraphs 4-26, 4-27, and 4-48. The proposed channel wall heights will be extended to station 177+00 to tie into high ground. It should be noted that the new channel invert actually will tie to the existing channel at station 164+40. If the existing channel meets Corps construction criteria, it is only necessary to provide a parapet wall between stations 164+40 and 177+00.

FREEBOARD

4-62 Minimum freeboard was set at 2.5 feet. A freeboard analysis similar to that described above for the mainstem Santa Ana River was done. The recommended channel was estimated to be able to carry a maximum of 5,800 ft^3/s to the Santa Ana River confluence without overtopping. In order for the proposed channel to carry the design discharge of 5,800 ft^3/s with a contemporaneous discharge of 65,500 ft^3/s in the mainstem, freeboard was increased to 5 feet at the confluence and gradually decreased to the minimum of 3.0 feet at station 140+00.

Phase I Compared to Phase II

4-63 The recommended Santa Ana River channel from station 535+30 to station 283+00 and station 150+32 to the ocean was redesigned from a rectangular cross section recommended in Phase I to a more cost effective trapezoidal section.

Interior Drainage Flood Control

GENERAL

4-64 Storm drain outlets have been designed to meet the goals outlined in EC 1110-2-247 "Hydrological Analysis of Interior Areas, Engineering Circular."

EXISTING CONDITIONS

4-65 From the upper end of the project to Chapman Avenue, Orange County has a series of storm drains that collect the storm runoff and empty into the Santa Ana River. The runoff along the right bank of the Santa Ana River from the Harbor Boulevard Bridge to Pacific Ocean is collected by storm drains and is drained away from the river, except in four localized areas where the storm runoff is collected and pumped into the river.

Along the left bank of the river from First Street Bridge to the Pacific Ocean, the Greenville-Banning Channel collects storm runoff and carries it parallel to the river before discharging into the ocean.

INVENTORY OF EXISTING DRAINS

4-66 A detailed investigation was conducted to identify and locate existing drains. A total of 152 drains and confluence structures have been identified, draining approximately 200 mi^2. A major task of the study was to identify the interior drainage area and flow capacity for each drain. A list of the storm drains is provided in the project plans, plate 72 for side drains and in tables 1 and 2, appendix E.

STORM DRAIN STUDY

4-67 A study was conducted to reduce flood losses at the storm drains. As a minimum design requirement, 100-year flood frequency capacity has been provided at the storm drain outlets as shown on the Side Drain Tabulation, appendix E. In order to determine the capacity of each drain, the 100-year peak flow in the drain was analyzed with the contemporaneous flow in the river. Contemporaneous river flow is equivalent to about a 15 to 20 year event as shown on plates 7-65 and 7-67 of volume 7. Drain nos. 88, 117, 118, and 133 will have storage ponds to hold the 100-year excess flow during the high river stage. The ponding areas adjacent to these drains are low depressions next to the levee that are used as recreation pathways or groundwater recharge basins. Outlet drains have been provided to interior detention storage ponds. Typical rating curves and flood routing for 100-year flood at side drain no. 88 are shown on plate IV-1.

4-68 At the junction of Greenville-Banning and Fairview Channel, the proposed project will aggravate interior drainage conditions for the area adjacent to the Greenville-Banning Channel. Under existing conditions, the interior drainage is handled by drain nos. 146, 147, 148, 149, and 150. The proposed project will cause blockage of the interior drainage during high river flood stage due to a higher water surface elevation in Greenville-Banning Channel. The higher water surface will be the result of relocating Greenville-Banning's outlet from the ocean to a confluence point one mile upstream on the Santa Ana River.

4-69 Several alternatives to handle the estimated 339 cfs maximum flow and 24 ac-ft storm volume were evaluated. The alternatives studied included: (a) a 150,000 gpm pump station, (b) a combination 60,000 gpm pump station and 6.3 ac-ft detention basin, (c) a combination 6.3 ac-ft and 17.7 ac-ft detention basin system connected by an inverted siphon under Fairview Channel, and (d) a single 24 ac-ft detention basin connected by an inverted siphon under Fairview Channel. The alternative selected was the combination 6.3 ac-ft and 17.7 ac-ft detention basin system, based on a comparison of costs, reliability, and availability of real estate. The recommended plan will consist of a diversion structure, two unlined detention basins located north (6.3 ac-ft) and

south (17.7 ac-ft) of the Fairview Channel, three drains with flapgates at the Greenville-Banning Channel, and a 6-foot diameter concrete inverted siphon under Fairview Channel. The basins will require excavation to a depth of about 7 feet below existing ground, and require an area of 4.5 acres of land (pl. 57).

4-70 Since the recommended plan will not raise the water surface for most of the river reaches, and only slightly (less than 1 foot) in portions of the reach between Katella Avenue and Imperial Highway, the drains will function as designed. No significant side drainage problems will be created by this important to the channel.

4-71 Side drain outlets which were analyzed for local SPF peak are shown in Table 2, Side Drain Tabulation, Appendix E. In order to determine the capacity of each drain, the local SPF peak discharge in the drain was analyzed with contemporaneous flow in the river. The contemporaneous river flow is equivalent to about 30 to 60 year event as shown on plates 7-65 and 7-67 of volume 7. When feasible and justifiable, local SPF storm peak runoff capacity is recommended for each side drain outlet. Project recommended drains are shown in the description column in table 2. Residual SPF flooding locations are shown on the drainage location maps, plates IV-2 through IV-4.

4-72 Additionally, the side drain outlets were analyzed for the contemporaneous general storm discharges. In this case the river design flow was used to determine drain capacities. This condition resulted in less flooding than that indication in the local SPF storm peak runoff analysis for all drains. For this reason a summary table for this condition is not included in this report.

References

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3. Vanoni, Vito, Ed., Sedimentation Engineering - ASCE M&R No. 54, American Society of Civil Engineering, New York, 1977.

4. Simons, Li & Associates., Engineering Analysis of Fluvial Systems, Fort Collins, Colorado, 19825.

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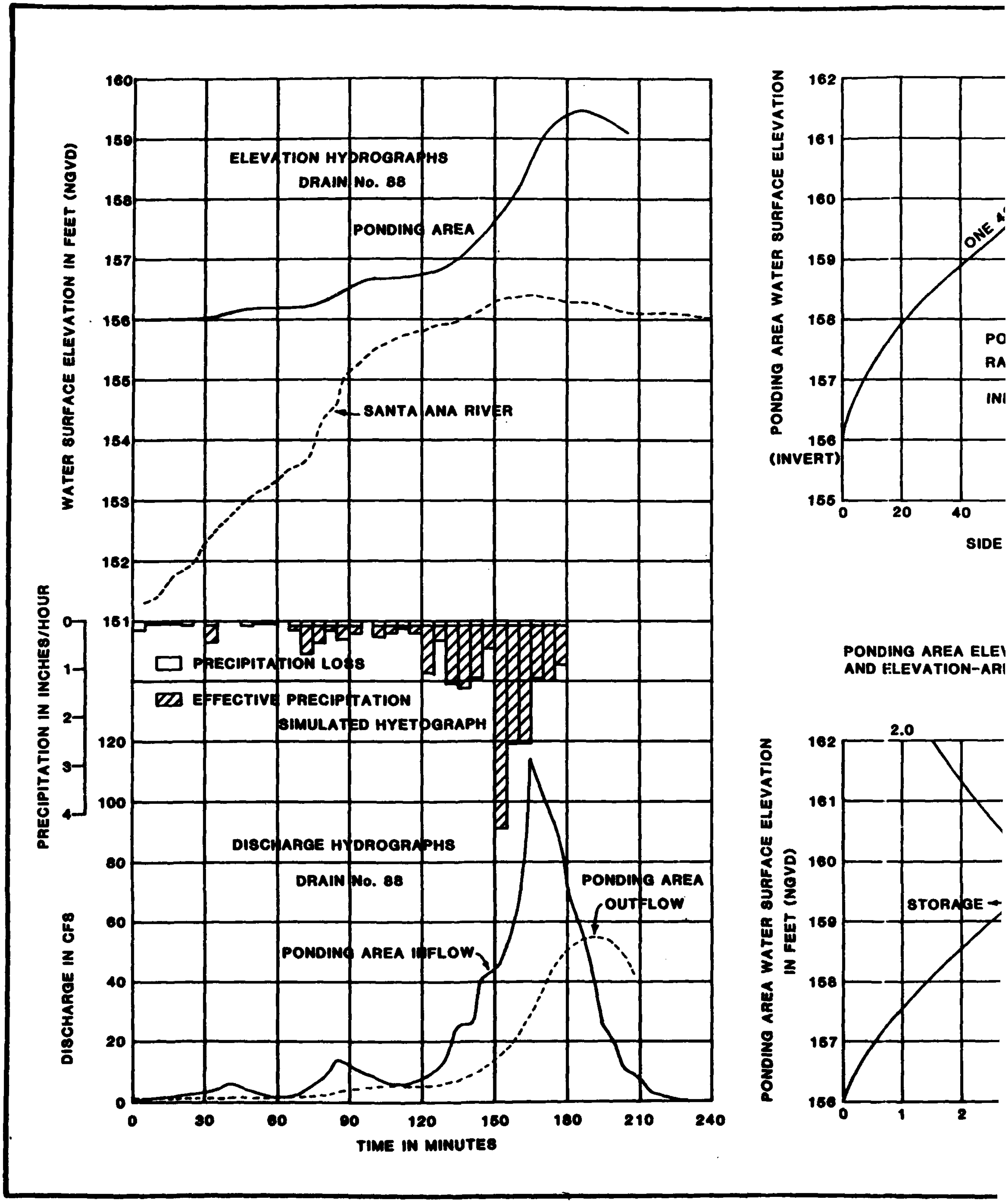
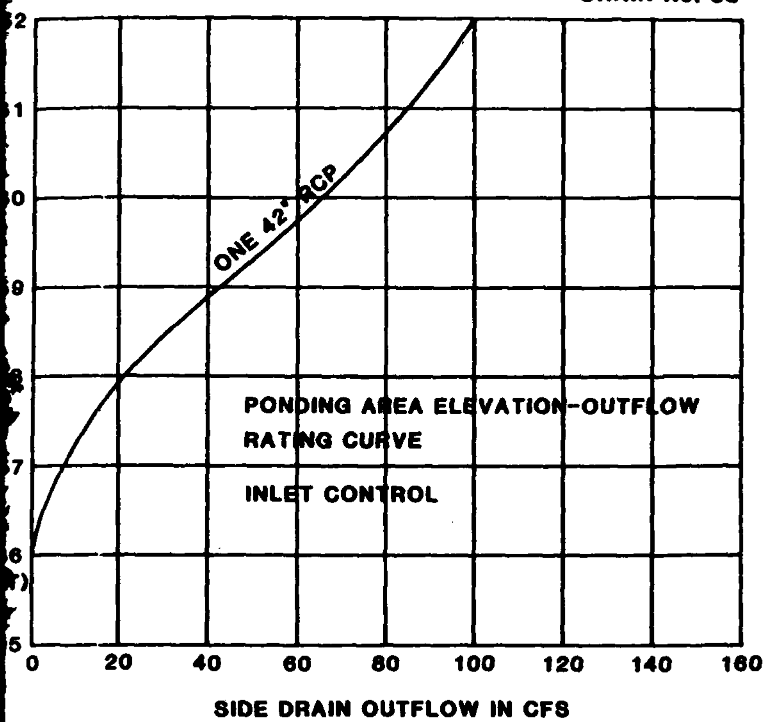
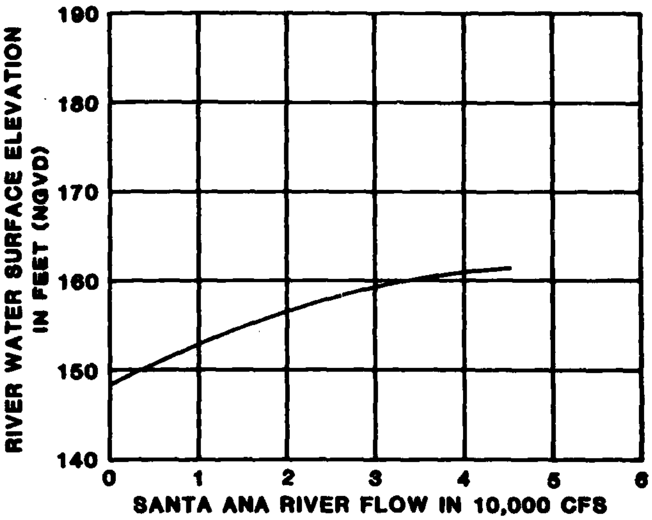
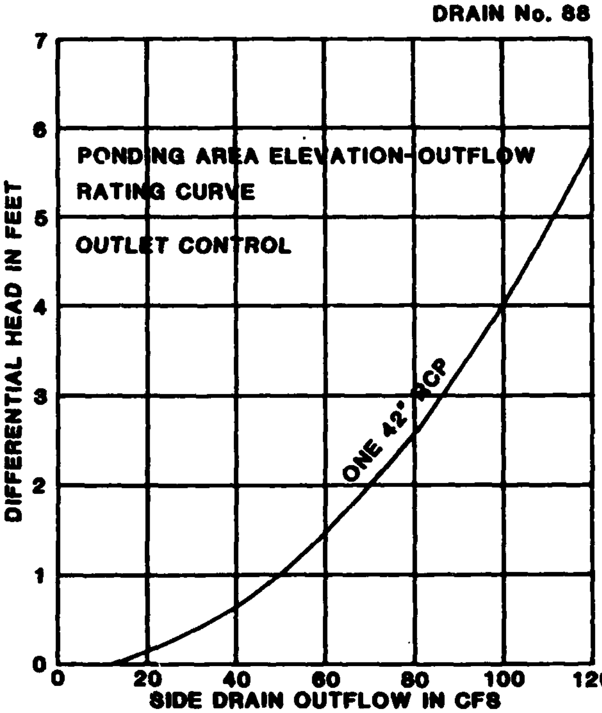
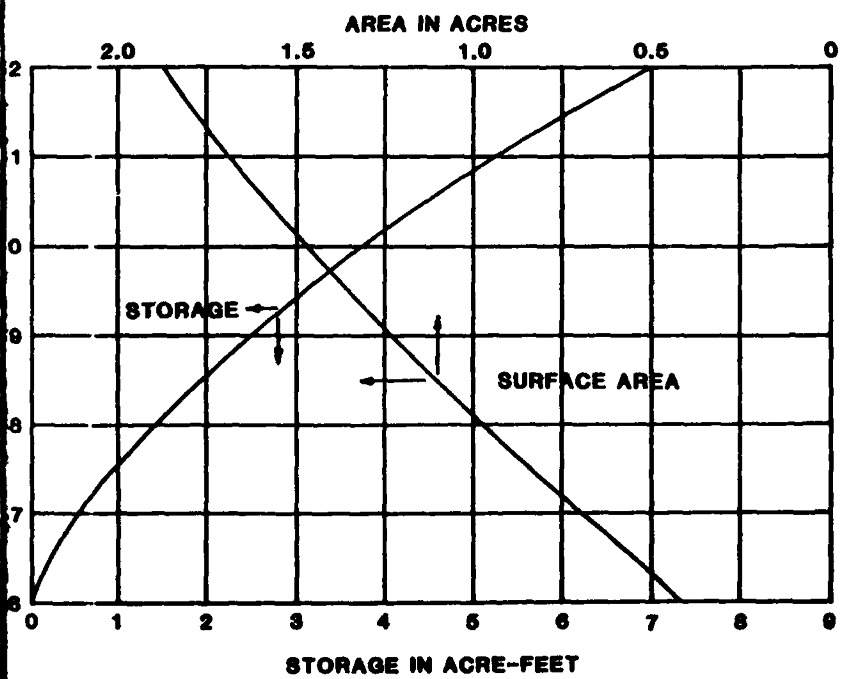

ELEVATION HYDROGRAPHS
DRAIN No. 88
PONDING AREA
SANTA ANA RIVER
WATER SURFACE ELEVATION IN FEET (NGVD)
PRECIPITATION IN INCHES/HOUR
PRECIPITATION LOSS
EFFECTIVE PRECIPITATION
SIMULATED HYETOGRAPH
DISCHARGE HYDROGRAPHS
DRAIN No. 88
PONDING AREA OUTFLOW
PONDING AREA INFLOW
DISCHARGE IN CFS
TIME IN MINUTES
PONDING AREA WATER SURFACE ELEVATION
(INVERT)
SIDE
PONDING AREA ELE
AND ELEVATION-AR
PONDING AREA WATER SURFACE ELEVATION IN FEET (NGVD)
STORAGE







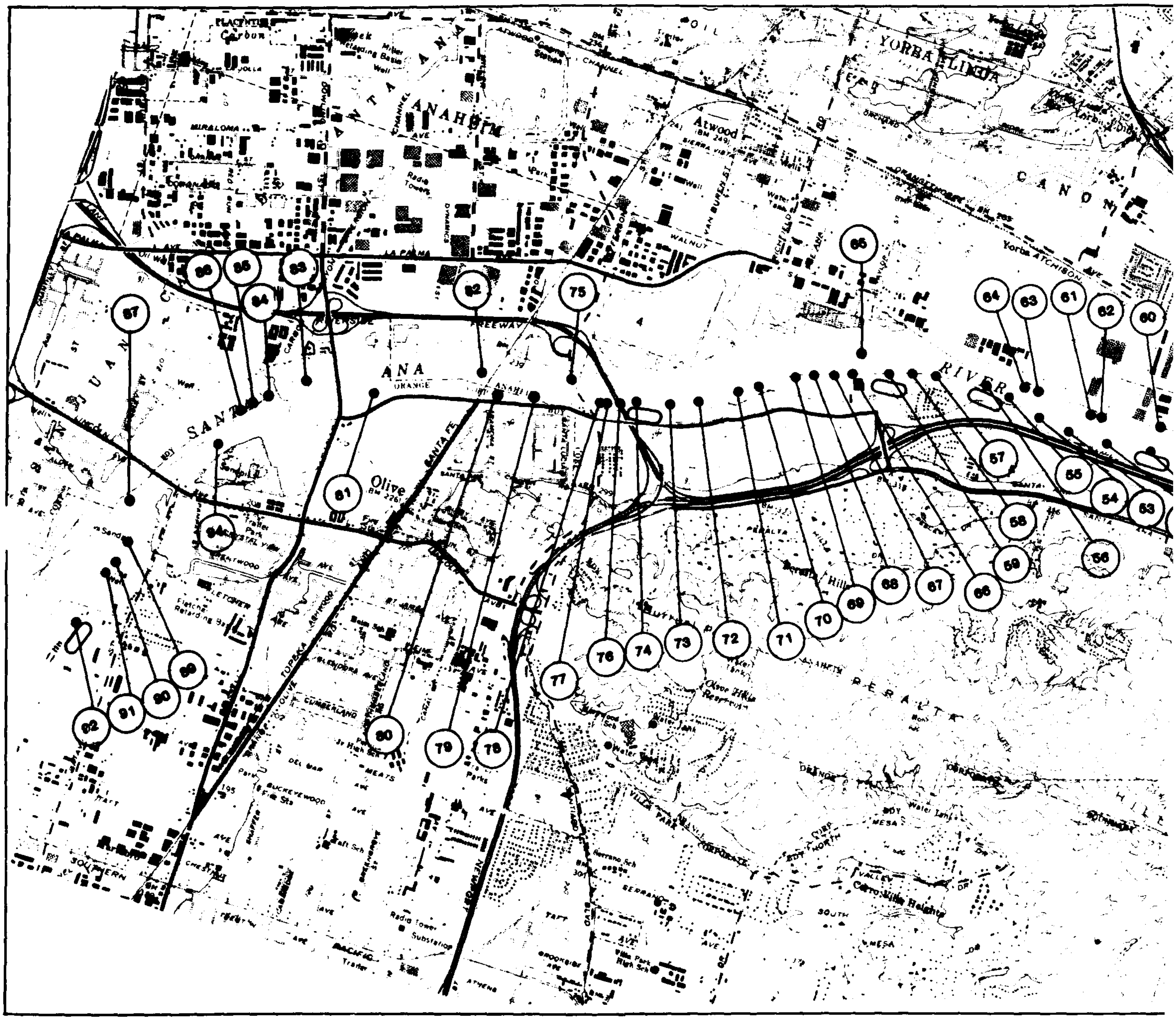


SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

INTERIOR FLOOD CONTROL
RATING CURVES AND FLOOD ROUTING
FOR 100-YEAR FLOOD
AT SIDE DRAIN No. 88 (TYPICAL)

US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE IV-1



YORBA LINDA
ANAHEIM
Atwood
CANON
RIVER
SANTA ANA
Olive
LA PALMA
FREEWAY
Yorba
ATCHISON
WALNUT
PERALTA
Peralta Hills
MIRALOMA
CUMBERLAND
TAFT
SERRANO
SOUTH
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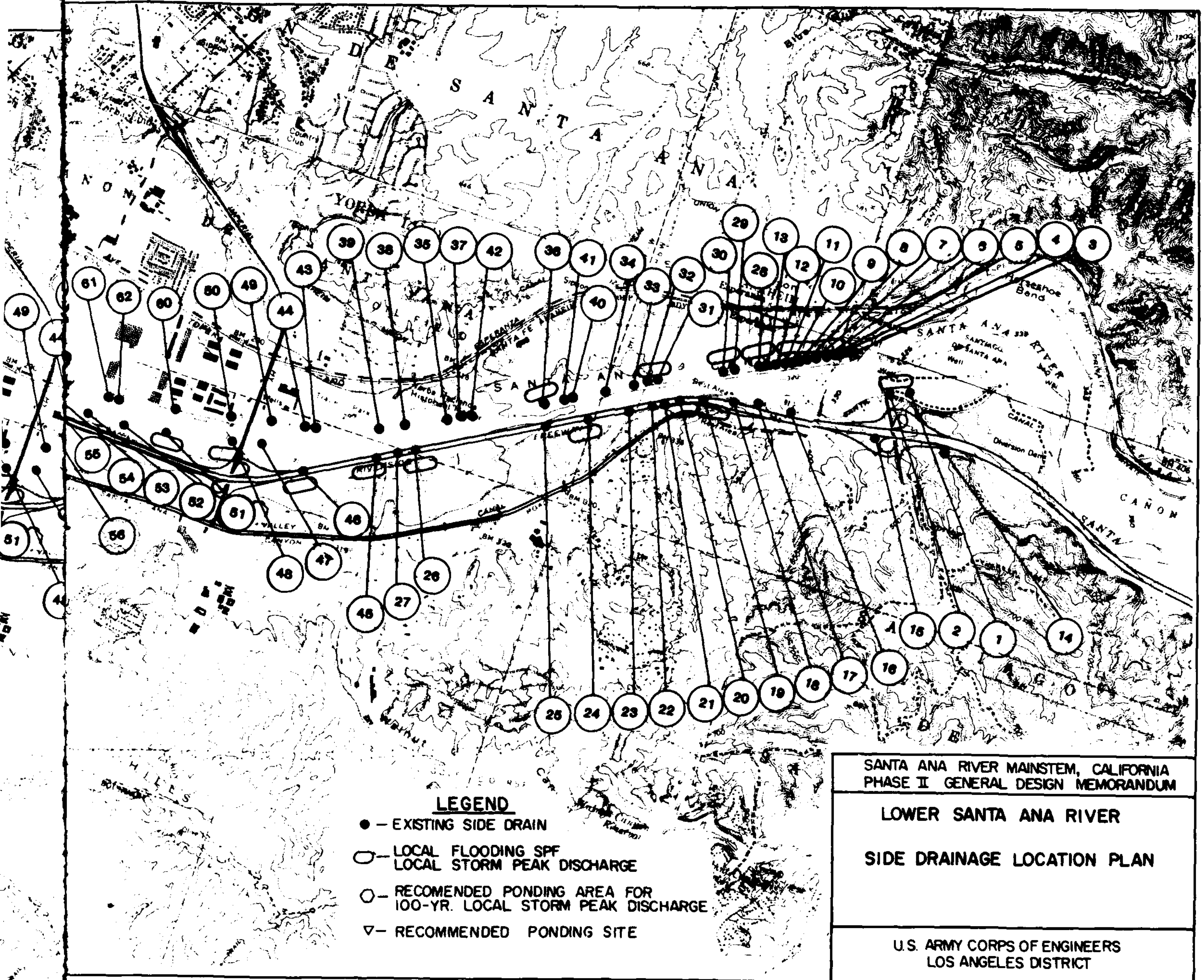

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER

SIDE DRAINAGE LOCATION PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE IV-2

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SANTA ANA
Jerome Park
BRISTOL
CLINTON
HARBOR
GROVE

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER

SIDE DRAINAGE LOCATION PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE IV-3

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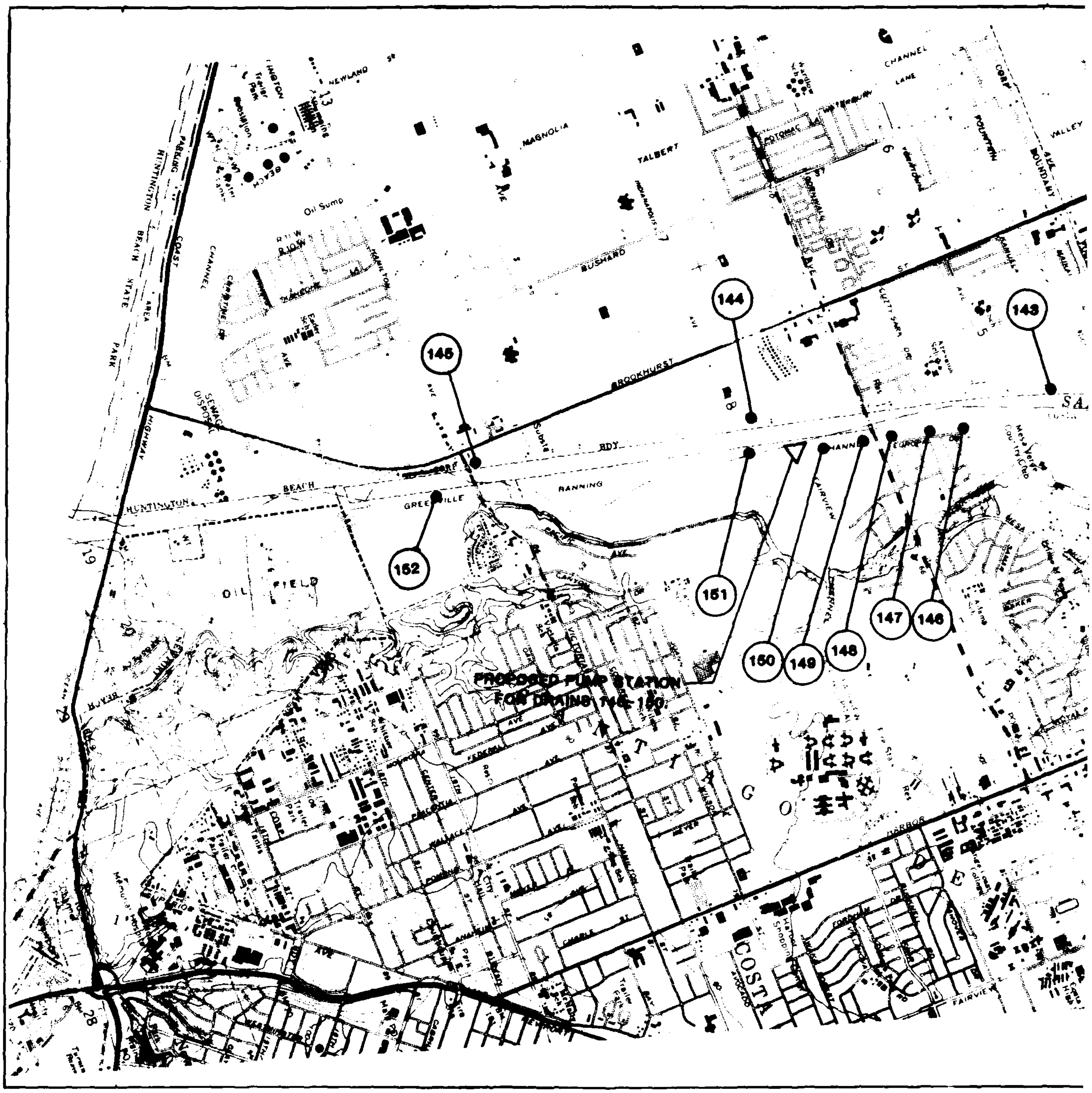

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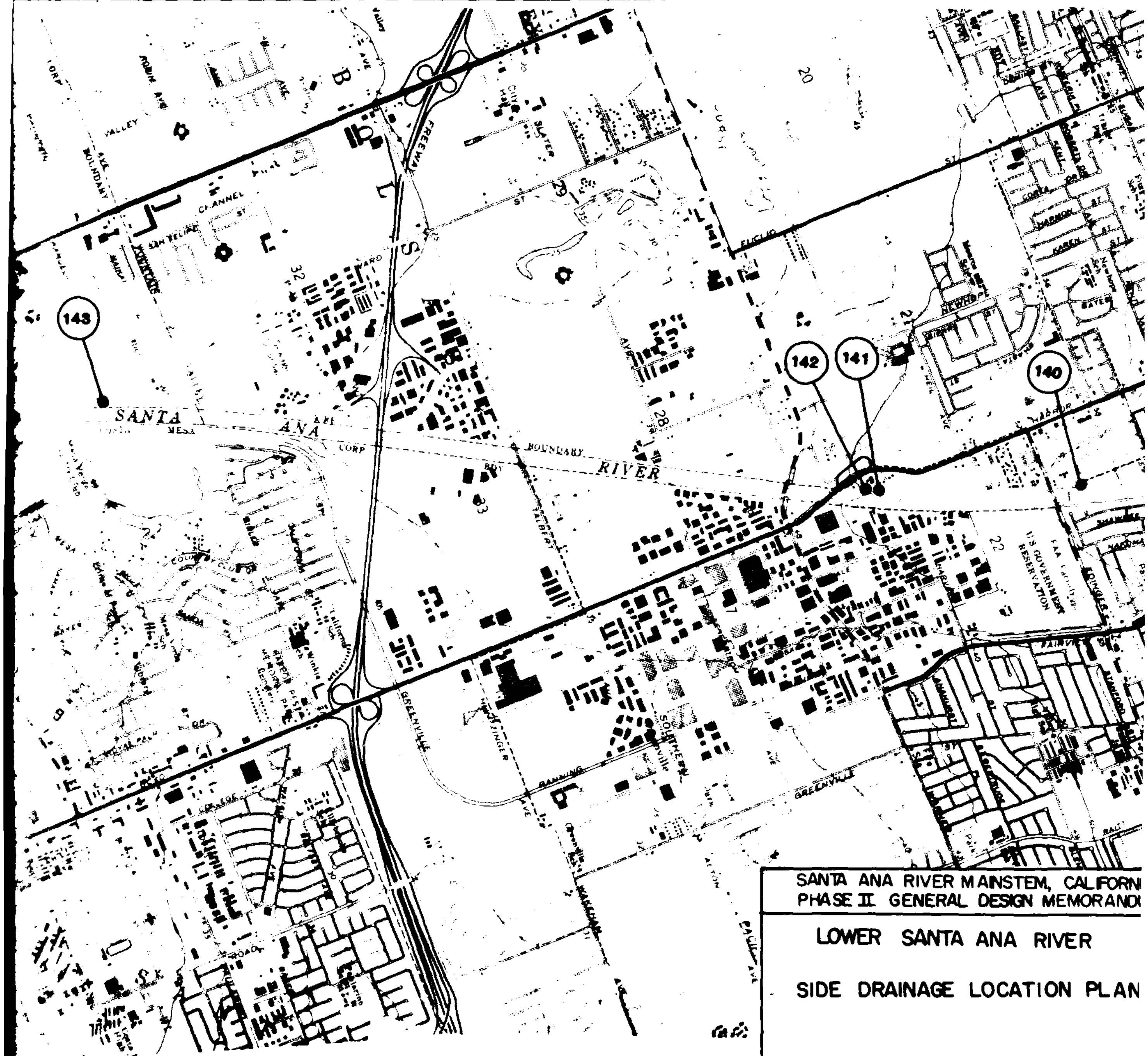
PROPOSED PUMP STATION
FOR DRAINS 146-150
NEWLAND
MAGNOLIA
TALBERT
BUSHARD
BROOKHURST
BANNING
GREENVILLE
HUNTINGTON
BEACH
HUNTINGTON BEACH STATE PARK
OIL FIELD
Oil Sump
CHANNEL
LANE
HARBOR
COSTA
FAIRVIEW



SANTA ANA RIVER MAINSTEM, CALIFORN
PHASE II GENERAL DESIGN MEMORANDU

LOWER SANTA ANA RIVER

SIDE DRAINAGE LOCATION PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

PLATE

2

V. COASTAL DESIGN

General

5-01 In addition to studies conducted by the Los Angeles District for coastal processes, a study for investigating the tidal exchange system at the mouth of the Santa Ana River was contracted with a private consultant. The detailed results of studies made for these features in connection with the flood control channel in the vicinity of the mouth of the Santa Ana River are presented in appendix B. The studies presenting the existing conditions and proposed improvements are described for the Santa Ana River and Talbert Channel jetties, tidal circulation, training dike structure, marsh restoration, beach replenishment considerations, and shoreline changes analysis.

Jetty Design

5-02 The proposed jetties and training dikes at the Santa Ana River and Talbert Channel outlets are designed in general accordance with the Shore Protection Manual published by the U.S. Army Coastal Engineering Research Center, 1984. The proposed jetties terminate at about the same location as the existing jetties to minimize adverse impacts on the surrounding beaches. The plan, profiles and cross sections for the jetties and training dike structures are shown on plates 75 and 76.

Tidal Circulation in Channel

5-03 The net direction of annual littoral transport in the vicinity of the Santa Ana River mouth has been toward the southeast or downcoast. There are distinct seasonal variations, with strong transport being to the southeast during the winter months and more moderate transport to the northwest during the summer months. The existing Talbert Channel has been partially open to the ocean a relatively high percentage of the time compared to the existing Santa Ana River mouth. The existing

Greenville-Banning Channel, which currently provides tidal exchange for the existing salt marsh to the east upstream of Pacific Coast Highway is closed over half the time and requires frequent maintenance. The proposed design to maintain tidal flows in the relocated Talbert Channel and proposed Santa Ana River channel include training dikes to replicate the existing Talbert Channel's tidal exchange characteristics, and limit the closure frequency. The study data indicates that the need for the Talbert Channel is marginal and its construction would be predicated on monitoring the performance of the relocated Talbert Channel to closure. However, a construction cost is included in the project estimates for the Talbert Channel relocation. The proposed training dikes will maintain or improve tidal exchange in each of the channels.

Marsh Design

5-04 The existing tidal exchange system for the salt marsh is through a manually operated gate located just upstream of Pacific Coast Highway through the Greenville-Banning Channel levee. The existing tidal exchange is poor due mainly to the frequent closures of the Greenville-Banning Channel and a relatively small tidal prism within the existing marsh. The proposed marsh design including regrading, planting, and the installation of tide gates at two locations along the proposed Santa Ana River channel are shown on plates 78 to 86. The proposed regrading will increase the area subject to inundation and the tidal prism volume within the marsh. The addition of tide gates at two locations along the Santa Ana River will improve circulation within the marsh. The City of Newport Beach has indicated a desire to have the Corps of Engineers extend and deepen the tidal channels beyond the proposed marsh restoration boundary. Plans, construction funding, environmental documentation for construction, and permit requirements would be the responsibility of the requester for the additional work. An official request is anticipated to be made to the Corps of Engineers in the future.

5-05 After completion of grading within the marsh and installation of the tide gates, the marsh will be allowed to come to equilibrium for the improved conditions prior to planting. Eradication of non-marsh plant species and planting of target species will occur 1 to 2 years after construction.

Beach Disposal

5-06 Excess material excavated from the channel will be placed directly on the beaches or near-shore zone mainly downcoast of the river mouth to replenish the existing beach. Based on construction of the first two reaches of the Santa Ana River and the Talbert Channel relocation, the following estimated suitable excess material is anticipated to be available at approximately 1 year intervals.

Reach 1 -	Santa Ana River (Pacific Ocean to Fairview Channel)	1,500,000 c.y.
	Talbert Channel Relocation - (Pacific Ocean to existing Talbert Channel)	250,000 c.y.
Reach 2 -	Santa Ana River (Fairview Channel to San Diego Freeway)	1,400,000 c.y.
		3,150,000 c.y.

During future maintenance of the channel, material suitable for beach placement would be disposed of on the beaches, mainly downcoast of the river mouth.

VI. GEOLOGY, SOILS, AND MATERIALS

General

The geologic and soils research and investigations contained in Appendix A were conducted in order to determine and evaluate the topography, geology and groundwater conditions of the Lower Santa Ana River and to determine the extent of the distribution and physical properties of the soil and any rock within the areas of proposed improvement. The appendix provides a description of the project area, the geology, faulting, seismicity, groundwater conditions, the geotechnical explorations and testing performed, the foundation condition in the project area, and the design values to be used in the project design. Recommendations are given for foundation treatment, embankment design, subdrainage system, beach compatibility, and design and construction considerations. A Feature Design Memorandum for concrete materials is planned to be complete prior to the start of construction of the first contract reach.

VII. STRUCTURAL DESIGN

General

7-01 This section presents the feature design for the structural elements for the proposed channel. The major elements of this project include open rectangular and trapezoidal concrete channel, transition structures, and confluences.

References

7-02 Design will be based on accepted engineering practice and will conform to the following Engineering Manuals (EM's), Engineering Technical Letters (ETL's), and Engineering Regulations (ER's):

References	Title
EM 1110-1-2101	Working Stresses for Structural Design
EM 1110-2-2000	Standard Practice for Concrete
EM 1110-2-2103	Details of Reinforcement - Hydraulic Structures
EM 1110-2-2502	Retaining Walls and Floodwalls (Draft Edition)
EM 1110-2-2902	Conduits, Culverts, and Pipes
ER 1110-2-1806	Earthquake Design and Analysis for Corps of Engineers Projects
ETL 1110-2-256	Sliding Stability
ETL 1110-2-312	Strength Design Criteria for Reinforced Hydraulic Structures

Other applicable ETL's, EM's (EM 1110-series), draft EM's, and codes listed therein.

Material Properties

7-03 Concrete design strengths will be based on 28-day compressive strengths of 3,000 and 4,000 psi. Design will be in accordance with applicable EM's and ETL's. Concrete and reinforcement properties are described in this paragraph.

Concrete	
Ultimate Compressive Strength	
Cast-in-place concrete	f'c = 3,000 psi
Reinforcing Steel Yield Strength	
ASTM Grade 40 steel or	fy = 40,000 psi
ASTM Grade 60 steel	fy = 48,000 psi
Modulus of Elasticity	
Concrete	Ec = 57,000 f'c psi
Steel	Es = 29,000,000 psi

Soil data, including unit weight of soil, allowable bearing pressure, angle of internal friction, equivalent fluid pressure are presented in paragraphs 6-12 and 6-18 in Appendix A, titled "Geotechnical."

Structures

RECTANGULAR CHANNEL

7-04 The walls of the open rectangular reinforced concrete channel will be designed as L-Type or U-Type retaining wall. For L-Type retaining walls, a 10-inch thick concrete invert with a center mat of reinforcement consisting of 5/8-inch diameter steel bars at 12 inches on centers in each direction, will be provided between the wall footings. The walls will be designed in pairs opposite each other with the wall footing abutting the 10-inch thick invert slab. This type of design will provide the necessary resisting force required for stability and will prevent sliding. For U-type retaining walls, the toe of each wall footing will be at the channel centerline.

7-05 Both L-walls and U-walls would be designed in accordance with EM 1110-2-2502 for four loading conditions. (1) Case I loading: earth pressure on the back of the wall would be determined in accordance with criteria contained in Civil Works Engineer Letter 64-7, 22 April 1964; Subject: "Construction Stresses in Retaining Walls". The lateral earth pressure would be computed for a condition of drained backfill. The triangle distribution of the horizontal earth pressure due to backfill material would be assumed in the design of the wall stem and footing. A vertical friction force with a coefficient equal to the tangent of 3/4 of internal friction angle (in degrees) of the backfill material would be assumed to act on the back of the walls. Straight line distribution of soil pressure would be assumed in the design of the wall footings. (2) Case II loading: In addition to the Case I loading, a maximum

loading of 200 psf due to construction equipment would be applied at the top of the wall; the loading then would be decreased by the unit lateral earth pressure Kw at each foot of depth. (3) Case III loading: Seismic force would be applied to the wall. The static lateral forces would be determined from the single wedge equation given in the manual. In addition to the static forces, the lateral forces produced by horizontal and vertical seismic accelerations acting on these wedges would be applied to the structural wedge for calculation of sliding and overturning stabilities. (4) Case IV loading: Wind force would be applied to the channel face of wall with no backfill behind the wall. This condition governs the design of channel face reinforcement and occurs only under construction.

7-06 Retaining walls would be located between station 195+00± and station 92+00± on the east bank of Santa Ana River. These walls would be designed same as rectangular channel wall described in paragraph 7-05.

7-07 The reinforced-concrete side slopes of the trapezoidal channels will have a slope of 1V on 2.H. The side slope paving, 10 inches thick will be reinforced with a center mat of No. 5 bars spaced 15 inches on center in both directions. The reinforced-concrete invert slab, 10 inches thick, and the low-flow channel slab, 12 inches thick will be reinforced with a center mat of No. 5 bars spaced 12 inches on center in both directions. The center low-flow channel slab is 12 inches thick to minimize future maintenance due to erosion caused by sediment abrasion on the concrete slab.

Transition Structures

7-08 Transition structures would be provided where the section changes from a trapezoidal section to rectangular section or vice versa. Transition structures would be designed with either "L" or "T" type channel wall. Design conditions will be the same as described under the heading "Rectangular Channel."

Confluences

7-09 The confluences will be provided where two channels join together. A divider wall at confluences will be designed for their respective differential water pressure against the wall between the two channels.

Side Drain Structures

7-10 Appropriate sizes of concrete drainage pipes will be provided to connect existing drainage pipes into proposed channel. Automatic drainage gates will be provided wherever required.

Highway Bridges

7-11 In accordance with requirements of local cooperation, local interests would provide for the design and construction or modification of existing bridges, the removal and replacement of existing paving and

the construction of detours where required. Provisions for existing side drains and proposed utility lines (gas, electric, water and sewer) would be incorporated into the design of bridges, where applicable. The highway bridges would be designed in accordance with standard specification of American Association of State Highway and Transportation Officials for HS 20-44 loading.

VIII. RELOCATION OF BRIDGES, STREETS, RAILROAD, UTILITIES, AND RECREATION TRAILS

General

8-01 There are 38 existing bridges including 32 streets, 5 railroads, and 1 bicycle bridge crossing the Santa Ana River from Prado Dam to the Pacific Ocean. Prior to the start of the Corps project, four additional structures will be constructed by the local sponsors. These will include the 19th Street bridge, the Santa Ana River and Talbert Channel bridges and a bicycle bridge located upstream from 17th Street. Under the recommended plan for the Santa Ana Channel, replacement of two street bridges and modification of 26 will be required. Modifications will include deepening of footings, addition of pier noses and pier nose footing scour protection. The remaining structures will be left in place. Construction of the bicycle bridge is scheduled for 1988 and the Santa Ana River and Talbert Channel bridges will be constructed in 1989-90 with the widening of Pacific Coast Highway project by the locals (CALTRANS).

Bridges and Streets

8-02 Since the Phase I report, a number of new bridges have been built, reconstructed or modified. New bridges have been constructed at Weir Canyon Road, Victoria-Hamilton, and Adams Avenue. Construction of a bridge at Gypsum Canyon will be completed in 1989. Hydraulic analysis were made for each bridge crossing along the channel to minimize replacement of the existing structures. Two bridges, Katella and Orangewood Avenue were judged to require reconstruction. Victoria-Hamilton Avenue bridge will be extended to accommodate the realignement of Greenville-Banning Channel. The remaining crossings will be modified as described in the above paragraph 8-01.

8-03 A listing of bridges requiring modifications or reconstruction with the estimated cost is shown in table VIII-2. Bridge modifications and replacements will be the responsibility of Orange County. During

construction of bridges, vehicular traffic crossing the river would be rerouted to another bridge or it could be constructed in stages where rerouting of traffic can be directed onto the portion of bridge already completed. Modification and replacement of bridges may be incorporated with the channel construction; however, it anticipated that the bridge replacements will be completed by the local sponsor prior to the Corps' construction.

Temporary Detours

8-04 Existing bridges at Orangewood Avenue and Katella Avenue will be reconstructed and a bicycle bridge at Victoria-Hamilton Street bridge will be extended. During construction of the bridges, detours will be made to direct traffic to adjacent streets where necessary. Final detour plans will be coordinated with Orange County. Tentative detour plans are described as follows:

a. Pacific Coast Highway - The new PCH bridge will be constructed in two stages by CALTRANS in conjunction with the widening of Pacific Coast Highway. Two new structures across the Santa Ana River to carry traffic in each direction respectively will be constructed parallel to the existing bridges. The existing bridge structure will be used for temporary crossing while the new bridges are constructed.

b. Victoria-Hamilton Avenue - This bridge will be extend easterly. The existing bridge will remain in place. Traffic would be rerouted to cross the Santa Ana River at the Pacific Coast Highway bridge or to the Adams Avenue bridge.

c. Bicycle Bridges - The existing bridge at station 139+40 will be reused as part of the new bridge. During construction, no bike traffic will be able to cross the river at this location. A new bicycle bridge at station 526+00 will be constructed by Orange County by summer 1988.

d. Orangewood Avenue - Traffic will be rerouted to cross the Santa Ana River at the Chapman Avenue bridge.

e. Katella Avenue - Traffic will be rerouted to cross the Santa Ana River at the Ball Road bridge.

Railroads

8-05 Five operating railroad bridges cross the Santa Ana River. The recommended channel designs can accommodate flows past each bridge without replacement of the superstructures. Minor modifications to the bridge substructure would be necessary for the Southern Pacific Railway Company at station 733+23 and to Atchison, Topeka and Santa Fe Railroad at stations 693+40 and 897+75. Modifications would involve extending the footing depths, adding pier noses, adding pier nose footing scour

protection and/or any combination of these. Initial coordination has been made with each railroad owner. All design for the railroad bridge modifications will be coordinated by the Corps of Engineers with the railroad owners.

8-06 The Orange County Rapid Transit District bridge, located at station 488+55, is the last remaining vestige of the former Pacific Electric Railway's Santa Ana line. The bridge, built in 1905, is a twin Pegram Truss structure with link and pin and riveted connections. Only relatively minor alterations have occurred to the bridge over the years. The bridge has been determined eligible for the National Register of Historic Places for its significant historical associations and its design characteristics. In addition, the bridge appears to be the last remaining example of its type in the state. As removal of the bridge is not necessary for the Corps project, the State Historic Preservation Officer, and ERB staff have recommended that the bridge be left in place and avoided by the project construction. The track has been removed by the owners and they have no future plans for its use. This structure is scheduled to remain in place.

Utilities

8-07 The alignment and grade of the proposed channel is designed to minimize relocation or modification of existing utilities which are currently crossing or parallel to the river. Utility relocations consist of modification or relocation of all existing gas, petroleum, water, sewer, power and communication lines that interfere with the proposed channel construction. There are no known utilities anticipated to be any problem that would influence any configuration, profile or relocation of the channel within the existing rights-of-way.

8-08 Utilities that will require relocation or modifications are shown on the project plans and tabulated on plate number 65. Existing utilities and a listing of known owners are shown in table VIII-1.

Recreation Trails

8-09 The existing recreation trails are considered similar to a utility and their replacements are treated as a relocation cost. The replacement of recreational trails will primarily be located on the channel maintenance roads. Any portion of the trail system not a part of the required maintenance road will be considered as a relocation. The location and routing of the trails is shown on plates accompanying the Main Report. Detailed plans will be developed as a part of the design process in the preparation of Plans and Specifications. Portions of the existing trail system have been funded under the Land and Water Conservation Fund Act. The Orange County Environmental Management Agency has assumed the responsibility of determining what clearances or appraisals are required in connection with this funding, or any other grant funding, and initiating the appropriate action to maintain compliance with all pre-existing contractural agreements entered into by the County of Orange and any other State or Federal Agency.

Table VIII-1. Utility Owners.

Existing Utility	Owner
Electrical	Southern California Edison Company
Sewer	Santa Ana Watershed Project Authority
Sewer	County Sanitation District of Orange County
Water	Metropolitan Water District
Gas	Southern California Gas Company
Water	Peralta Hills Water Company
Gas	Four Corners Pipe Company
Telephone	Pacific Telephone Company
Television	Cable Vision of Orange
Water	City of Santa Ana
Electricity	City of Anaheim
Water	City of Anaheim
Water	City of Orange, Water Department
Gas	Gatron Industries, Inc.
Water	Mesa Consolidated Water District
Sewer	City of Newport
Oil	Standard Oil Company

Table VIII-2. Pertinent Informati

Name	Station	Width	Length	No. Spans	Type	Proposed
Pacific Coast Highway-SAR	16+82	N/A	N/A	5	P/S Concrete	Reconstruct: By others
Pacific Coast Highway Talbert Channel	N/A	N/A	N/A	N/A	Conc. Slab	New construction By others
19th Street/ Banning Avenue	63+50	86'-0	715'-0"	4	Box Girder	New construction By others
Victoria/ Hamilton	90+45	80'0"	448'0"	10	Box Girder	Modify and extend bridge
Bicycle Bridge #1	139+33	14'0"	290'0"	3	Steel Truss	Reconstruct:
Adams Avenue	171+84	94'0"	536'2"	5	Box Girder	Remain
San Diego Freeway	262+15	188'6"	440'1"	6	Box Girder	Remain
Talbert Avenue	289+11	80'0"	297'11"	7	Box Girder	Remain
Slater-Sergerstorm	318+39	76'0"	327'6"	5	Conc. T-Beam	Remain
Warner Avenue	341+35	76'0"	254'1"	6	Conc. T-Beam	Remain
Harbor Boulevard	349+85	78'0"	377'8"	8	Steel Girder/ Conc. T-Beam	Remain
Edinger Avenue	392+83	52'0"	299'8"	7	Conc. T-Beam	Remain
McFadden Avenue	429+12	66'0"	376'10"	7	Conc. T-Beam	Remain
Bolsa Avenue	459+22	59'11"	437'0"	9	Arch T-Beam	Remain
5th Street	473+54	57'8"	320'1"	7	Conc. T-Beam	Remain

ertinent Information on Highway Bridges.

Proposed	New Width	New Length	Remarks	Cost
econstruct: y others	118'0"	563'0"	Replaces existing bridge. Construction by Caltrans - 6/89. PCH widening project	-
ew construction y others	110'-0	176'-0	Part of PCH widening project	1,548,000
ew construction y others	86'-0	715'-0	New construction by others	0
odify and extend ridge	80'0"	619'0"	Additional 2 spans @ 85'6" + Pier nosing on 2 piers	1,552,500
econstruct:	14'0"	510'10"	Extend existing bridge - reuse 220'10" wood deck with prefab steel truss	503,700
emain	-	-	Modify abutments	250,000
emain	-	-	Modify abutments; add pier nosing	350,000
emain	-	-	Modify footings	172,500
emain	-	-	Modify footings	172,500
emain	-	-	Modify footing; add pier nosing	300,000
emain	-	-	Modify footing; add pier nosing	350,000
emain	-	-	Modify footing; add pier nosing	300,000
emain	-	-	Modify footing; only	225,000
emain	-	-	Modify footing; add pier nosing	325,000
emain	-	-	Modify footing; add pier nosing	325,000

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Table VIII-

Name	Station	Width	Length	No. Spans	Type	Propos
Orange County Rapid Trnst. Dist.	488+55	18'	400'-0"	2	Steel Truss	Remain
Fairview Street	508+57	52'0"	496'4"	9	Conc. T-Bean	Remain
17th Street	521+19	92'0"	357'9"	4	Conc. T-Beam	Remain in
Bicycle Bridge #2	526+00	14'-0"	315'-0"		Steel Truss	New constı
Garden Grove Boulevard	582+91	65'7"	610'6"	15	Arch T-Beam/ Conc. T-Beam	Remain
Garden Grove Freeway	603+11	130'4"	569'2"	9	Conc. T-Beam	Remain
Southern Pacific Railroad	624+34	20'0"	567'0"	7	Steel Truss & Girder	Remain
Santa Ana Freeway	625+39	114'0"	520'0"	10	Conc. Arch T-Beam/Box Girder	Remain
Chapman Avenue	638+76	100'0"	388'10"	5	Conc. Box Girder	Remain
Orangewood Avenue	668+86	71'0"	348'10"	7	Conc. T-Beam	Reconstru
Orange Freeway	682+32	172'0"	912'11"	8	Conc. Box Girder	Remain
Atchison, Topeka & Santa Fe R.R.	693+40	15'0"	1147'6"	13	Steel Girder	Remain
Katella Avenue	708+93	61'2"	301'7"	7	Conc. T-Beam	Reconstru

VIII-2. (Continued)

roposed	New Width	New Length	Remarks	Cost
n	-	-	Remodel, renovation Possible historic designation	73,000
	-	-	Modify footing	400,000
n in place	-	-	No work	0
onstrution	-	-	Reconstruction purposes only scheduled construction - 1988	0
n	-	-	Modify ftgs. add pier nose, and scour protection	536,000
n	-	-	Add pier nosing and scour protection	510,000
n	-	-	Modify footing	200,000
n	-	-	Add pier nosing and scour protection	345,000
n	-	-	Scour protection	87,000
nstruct	71'0"	370'0"		3,376,000
n	-	-	Scour protection	112,000
n	-	-	Pier modification	150,000
nstruct	61'2"	373'0"	New structure under design	3,437,000

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Table VII-

Name	Station	Width	Length	No. Spans	Type	Propose
Southern Pacific Railroad	733+25	17'0"	420'0"	6	Prestressed Box Girder	Remain
Ball Road	749+29	81'0"	397'0"	6	Conc. T-Beam	Remain
Lincoln Avenue	821+45	68'0"	426'6"	6	Conc. T-Beam	Remain
Glassell Street	865+74	63'7"	963'0"	9	Conc. Box Girder	Remain
Atchison, Topeka & Santa Fe R.R.	897+75	19'0"	474'6"	6	Prestressed Box Girder	Remain
Tustin Avenue	918+33	74'0"	862'5"	6	Conc. T-Beam	Remain
Riverside Freeway	926+32	140'0"	869'6"	18	Conc. T-Beam	Remain
Lakeview Ave.	983+49	79'0"	398'6"	6	Conc. T-Beam	Remain
Imperial Highway	1065+61	91'0"	367'11"	4	Prestressed I-Beam	Remain
Weir Canyon Road	1207+19	88'0"	775'0"	6	Conc. Box Girder	Remain
Gypsum Canyon Road	1347+15	78'-0"	1770'-0"	7	Prestressed Box Girder	By others
Green River Golf	1479+20	28'±	90'±	1	Steel Plate Girder	Remain
Atchison Topeka & Santa Fe R.R.	1512+20	18'-0"	657'6"	7	Steel Truss	Remain
Corona Freeway	1612+00	33'8"	502'0"	5	Steel Plate Girder	Remain

able VII-2. (Continued)

Proposed	New Width	New Length	Remarks	Cost
lemain	-	-	Modify abutments & scour protection	198,000
lemain	-	-	Scour protection	98,000
emain	-	-	Scour protection	95,000
lemain	-	-	Scour protection	121,000
lemain	-	-	Scour protection	87,000
emain	-	-	Scour protection	119,000
emain	-	-	Add pier nosing/connect pier walls & scour protection	818,000
emain	-	-	Scour protection	97,000
emain	-	-	Scour protection	61,000
emain	-	-	Scour protection	68,000
y others	-	-	Under construction, completion Jan 1990	0
emain	-	-	No work - bridge to golf club house	0
emain	-	-	No work	0
emain	-	-	No work	0

IX. ACCESS ROADS

General

9-01 The berm on both sides of the recommended channel is used as the vehicular access road for the inspection and maintenance of the flood control project. Within the 15-foot-wide berm, a 12-foot road will be paved with asphaltic concrete to permit all-weather usage of the berm. The access road is joined to a public street wherever possible, or a turnaround is provided where necessary. The paved roads provide dual usage for the biking and hiking/equestrian (recreation) trails.

Geometric Design

9-02 Vehicular access roads, including ramps, will be designed in general accordance with the report entitled "A Policy on Geometric Design of Rural Highways" by the American Association of State Highway and Transportation Officials, and will be based upon design criteria determined from the expected traffic makeup and volume. A maximum vertical grade of 10 percent and a minimum vertical curve length of 90 feet will be used in the design. A 2 percent cross slope towards the river will provide for access road drainage.

Pavement Design

9-03 The flexible pavement forming the access road will be designed in general accordance with Department of the Army TM 5-822-5. Based on tests on similar type of materials, a subgrade CBR value of 20 is assigned when compacted to 95 percent of maximum density as determined by ASTM Test Method D-1557. The flexible pavement will be designed for the following values:

Category of Traffic: III
Class of Road: F
Design Index: 2

The pavement section for the access road consists of a 2-inch layer of bituminous surface course over 6-inch thick subgrade compacted to at least 95 percent of relative density. The section for equestrian trails consists of only a cleared and graded section on native soil.

Fencing

9-04 A 5-foot chain link channel fence will be placed along the top of all vertical channel walls. Rights-of-way fencing will consist of 6 foot chain link fencing.

X. RECREATION

General

10-1 Biking and hiking/equestrian trails are provided for the project. The maintenance and access roads will serve a dual purpose as bikeways and trails on respective sides of the channel. Existing trails that are located off the maintenance road and are affected by new channel construction will be relocated. A new trail system will be constructed in the upper Santa Ana Canyon area which will incorporate a separate trail, a separate bikeway or a combined trail system. The trail system in the canyon has been coordinated with Orange and Riverside Counties and will tie into recreational plans for Prado Dam. The trail system and detailed elements are fully discussed in appendix D.

10-2 During construction, the use of existing access roads and trails will be allowed where feasible. Temporary detours and relocation of trails will be utilized as much as possible to provide opportunities for recreational usage within the existing and proposed channel.

10-3 The cost for construction of trails in the upper canyon area is a separable cost attributed to recreation, and will be cost shared on a 50-50 basis with local interests. The local sponsor is responsible for all maintenance and operation.

XI. ENVIRONMENTAL EVALUATION

General

11-01 An Environmental Impact Statement (EIS) on the proposed flood control improvements along the mainstem of Santa Ana River was presented in the Phase I General Design Memorandum (GDM) dated September 1980. For this Phase II GDM, the environmental evaluation has been updated and broadened. Details of the findings and concerns are presented in the Supplemental Environmental Impact Statement included in the Main Report of this Phase II GDM. This section presents a brief description of the environmental impacts which may be caused by the project.

Environmental Impacts

SEDIMENTATION

11-02 In the long term, sediment is expected to increase. It is estimated that an additional 10,000 cubic yards annually (approximate) will reach the ocean. The increase is due to the higher channel capacity releases made possible from Prado Dam with the project.

WATER RESOURCES

Hydrology and Water Use

11-03 Impacts to hydrology and water use have not changed significantly from the 1985 Phase I SEIS.

Water Quality

11-04 Water quality in the lower river will be impacted by construction activities of this project, including disposal of suitable excavated material into the near-shore zone. Turbidity and possible organic material will be introduced into the ocean and river channel. Least tern feeding at the river mouth may be affected by the turbidity.

Oxygen depletion as a result of sediment organic material being present is a possibility. Since the channel will be deepened, increased salinity and ponding will occur. Eutrophication may take place if the channel entrance should become closed and tidal flushing does not occur. Also, the appearance of water created by turbidity may impact recreation use.

AIR QUALITY

11-05 Impacts to air quality will be local and short term, due to construction activities, and will primarily be associated with vehicle emissions and dust generation. Increased vehicle emissions would result from heavy equipment use on the construction site, trucks hauling borrow materials to the construction site, and from personal vehicles driven by construction workers.

LAND USE AND SOCIAL CONCERNS

Farmlands

11-06 Some farmlands occur at the south end of the Santa Ana canyon. These lands are located on limited acreages and are mainly orange groves not considered prime or unique farmlands. Some of these lands will be impacted by the acquisition of floodway for floodplain management, and management for open space and wildlife habitat values.

Recreation

11-07 There will be no long-term impacts to existing recreation with the proposed project. Short-term impacts, i.e., closure and/or rerouting of the existing bicycle and jogging trails, will occur during construction.

Growth Inducement

11-08 Growth inducement is not expected to occur as a result of improvements made to the lower river. Currently, the lower river area is rapidly urbanizing in those areas where development can still occur.

TRANSPORTATION AND UTILITIES

Facilities

11-09 Use of freeways and local streets will be necessary during construction of the project. Two railroad crossings (bridges) will be modified, however, service would not be interrupted. Bridge replacements will occur on two bridges, and modification on 26 bridges. Detours will be necessary when these replacements occur.

Transport of Borrow Materials

11-10 Transport of borrow materials for channel construction will mostly occur within the channel construction area (summer months). Local roads and highways will be used for work outside the channel, and for channel work in the winter months.

NOISE

11-11 The lower river runs through a relatively quiet rural area in the Santa Ana Canyon, but from Weir Canyon Road, it crosses an intensely-developed urban area. Human-induced noise, due to the presence of freeways and railroads, is quite high in this lower section of the river. The marsh area, at the mouth of the river, receives a moderate noise level from oil drilling operations and the presence of the Pacific Coast Highway, so construction activities are not expected to significantly impact the marsh. The project will have local short-term impacts to the environment, as construction-related noise will be present.

BIOLOGICAL RESOURCES

Vegetation and Wildlife

11-12 In the SEIS for the Phase I GDM, a commitment was made to acquire all land within the post-project flood plain from Prado Dam to Weir Canyon Road for flood plain management in keeping with open space and wildlife habitat values. At the time, the flood plain was about 1,500 acres. The commitment has not changed with the Phase II GDM. However, the area within the flood plain has been revised to about 1,123 acres. These lands will be acquired for flood plain management and will be operated and maintained for open space and wildlife habitat values. The changes in the flood plain are due both to a revised and refined hydrological analysis and to development which has occurred within the original 1,500 acres. Most of the area that has been lost was in agriculture at the time the Phase I SEIS was prepared. Because the changes reflect improved hydrological analysis and development beyond the control of the Corps of Engineers, and because the purpose of the land acquisition is flood plain management, additional off-site lands will not be acquired to replace the 377-acre difference in the flood plain between the Phase I and Phase II documents.

Weir Canyon Road to Hamilton/Victoria Avenue

11-13 Modifications to about 21.5 miles of existing flood control channel in this river reach will permanently or temporarily destroy about 1,150 acres of generally low quality wildlife habitat. Deepening the 3 miles of modified flood control channel between Weir Canyon Road and Imperial Highway will impact about 200 acres of disturbed habitats. This total includes all rights-of-way. Provision for the construction of three drop structures should increase the potential for temporary development of wetland vegetation. Upgrading the existing

soft bottom channel and levees along the 7-mile reach of the river between Imperial Highway and Katella Avenue will affect about 460 acres of disturbed channel and modified upland habitats. Better quality wetland habitat that occurs in the vicinity of drop structures will be destroyed. However, wetland habitat should re-establish at the new modified drop structures. The spreading basins adjacent to the flood control channel, which provide considerably greater resource values to wildlife than the channel, will not be impacted by the project.

11-14 Project activities from Katella Avenue to 17th Street will impact about 240 acres of earth bottom flood control channel. Removal of an existing drop structure will cause the destruction of wetland. Provision for two new drop structures will provide new area for better quality wetland habitat to develop along the mostly disturbed soft bottom channel.

11-15 Construction of about 7 miles of rectangular and trapezoidal concrete channel from 17th Street to about Hamilton/Victoria Avenue will permanently destroy about 250 acres of low value wildlife habitat having little vegetation. Although wildlife values are presently low throughout this reach, the proposed concrete channel will remove these values and replace them with a very sterile area.

Hamilton/Victoria Avenue to the Santa Ana River Mouth

11-16 Implementation of the project will eliminate approximately 8 acres of mostly degraded high salt marsh east of the existing Greenville-Banning Channel, and temporarily affect 66 acres of intertidal and subtidal marine habitats within the Santa Ana River and Greenville-Banning Channels.

11-17 Widening of the Santa Ana River will eliminate approximately 4.5 acres of wetlands along the western edge of Victoria Pond. As mitigation for this impact, Victoria Pond will be reconstructed to its original size, south and east of its present location (fig. 8). The edges of the Pond will be revegetated with native wetland species. Restoration of Victoria Pond has been coordinated with the U.S. Fish and Wildlife Service and California Department of Fish and Game.

11-18 Widening of the Santa Ana River Channel to include the present Greenville-Banning channel will have long term beneficial effects. It will increase intertidal and subtidal habitats from 50 to approximately 101 acres. A larger tidal prism may help reduce the adverse effect of freshwater runoff on marine invertebrates, perhaps reducing the losses of benthic fauna.

11-19 Design changes from T-walls to trapezoidal riprap side slopes within the same right-of-way will reduce marine habitats by approximately 20 acres. This reduction in area is offset by the presence of sheltered marine habitats among the riprap side slopes for invertebrates and fishes, which will also provide resting and foraging habitat for shore birds.

Least Tern Nesting Site

11-20 Implementation of the Santa Ana mainstem improvements would not produce any direct impacts on the California least tern nesting sanctuary at Huntington Beach. Realignment of the Talbert Channel up coast of the nesting sanctuary and widening of the Santa Ana River mouth will produce some short term temporal losses in benthic resources. This loss will be offset by improvements in habitat values of the Santa Ana River salt marsh and the Huntington Beach wetlands conservance salt marsh after construction of the project. The realignment of the Talbert Channel up coast will benefit the least tern colony by further isolating the sanctuary. Phasing of construction activities to avoid impacts to the terns during the nesting season will also help in reducing construction impacts.

Talbert Channel

11-21 Realignment of the Talbert Channel to a position upcoast from the present Huntington State Beach California least tern nesting sanctuary will impinge on a portion of the 17-acre salt marsh and result in temporary short term losses of the benthic resources present in the existing channel.

11-22 The proposed realignment will have the beneficial impact of providing the needed tidal connection to the 17-acre salt marsh restoration project the Huntington Beach wetlands conservancy being restored by and further isolate the California least tern sanctuary from disturbances during the nesting season. After temporal losses to benthic resources have recovered to pre-construction levels in the new Talbert Channel it will provide a new upcoast foraging area adjacent to the least tern colony during the nesting season.

Santa Ana River Salt Marsh

11-23 Project construction will eliminate approximately 8 acres of mostly degraded high salt marsh east of the Greenville-Banning Channel. Use of the Santa Ana River Salt Marsh as a compensation site, for biological impacts resulting from project construction in the lower Santa Ana River, will produce direct and temporal impacts to habitat values during the implementation of the marsh restoration project.

11-24 The 92-acre salt marsh restoration and enhancement will provide valuable new and improved habitat for wetland dependent species. Creation of additional shallow water feeding habitat will benefit the California least tern. Also, recontouring the marsh and improving tidal flushing in the estuarine wetlands should increase the likelihood that the area would support resident populations of the endangered light-footed clapper rail and state endangered Belding's savannah sparrow. For details of salt marsh restoration project refer to plates 78 thru 85.

CULTURAL RESOURCES

11-25 In the Santa Ana Canyon, one prehistoric site and 15 historic sites have been identified as being potentially affected by the project. Of the 15 historic sites, 4 may be eligible for inclusion into the National Register of Historic Places. The prehistoric site is not eligible for the National Register. In the lower river three historic railroad bridges have been identified; only one is eligible for inclusion into the National Register of Historic Places. It is possible to avoid impacts to this bridge. The current plans call for avoidance of this bridge. There is a slight possibility that a historic shipwreck may be present in the area to be indirectly affected off the mouth of the river.

Mitigation

BIOLOGICAL RESOURCES

Santa Ana Canyon

11-26 No mitigation will be required.

Weir Canyon Road to Hamilton/Victoria Avenue

11-27 New or rebuilt drop structures in the soft bottom channel will be designed, if possible, to enhance development of wetland habitat.

Hamilton/Victoria Avenue to Santa Ana River Mouth

11-28 Due to the realignment of Greenville-Banning Channel, approximately 4 acres of Victoria Pond wetlands will be replaced by recreating similar habitat connected to the remaining section of the pond. Design of the enlarged and recreated pond was coordinated with the resources agencies.

11-29 Restoration of 92 acres (8 acres for mitigation and 84 acres for preservation and enhancement) of the Santa Ana River Salt Marsh was coordinated with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and California Department of Fish and Game.

11-30 Widening the Santa Ana River Channel and modifying and/or relocating the Greenville-Banning and Talbert channels will be completed to the extent possible outside of the nesting season (April to August), to prevent adverse impacts to California least tern feeding habitat.

11-31 Prior to project-related destruction of existing California least tern feeding habitat, the 92-acre salt marsh restoration project and Victoria pond wetlands projects will have been completed.

11-32 An alternative feeding program (fish stocking) will be implemented if the wetlands restoration projects are not fully functional as feeding habitat for California least terns during the nesting season. Future biological monitoring of turbidity during dredging/beach disposal may be implemented to assess impacts to the terns foraging areas.

XII. ESTHETIC TREATMENT

General

12-01 The Santa Ana River from the Prado Flood Control Reservoir to the Pacific Ocean covers a distance of approximately 30 miles. The environmental setting adjacent to the river ranges from the riparian and grassland biological communities in the upper reaches, through the intense and highly developed urban mid-reaches with regional and neighborhood parks, and water conservation operations, to the light and heavy industrial setting surrounding the lower reaches. Some reaches already have highly developed landscape treatment, especially the southern levee along the mid reach, while others especially the northern levee of the mid reach and the lower reaches have none. The development of an effective, esthetic treatment program for the entire Santa Ana River will be a highly visible and politically sensitive issue. The river, as it runs between the Cities of Anaheim and Santa Ana, is clearly visible from the superior viewpoint of three major freeways, four surface streets, and Anaheim Stadium. The project will be constructed in ten different segments over an 8 year period. During preparation of plans and specifications, a definative design would be prepared to develop a consistent and coordinated design approach for the entire river, and prescribe specific treatment for each site specific reach. The plans would include appropriate plant materials, both native and exotic, based on local needs and ecological evaluation. Irrigation needs will be based on utility availability and groundwater levels. Coordination with the County of Orange, the various cities, and local citizens groups will ensure that an esthetic treatment plan is developed that expresses and is responsive to customer needs is implemented.

Visual Treatment

12-02 The esthetic treatment program would provide visual variety and special definition to break up the flat vistas and long reaches of the channel. Plant materials would be the dominant factor in providing visual diversity and screening, and would be selected based on scale,

color, and texture. Focal points would be developed for visual interest, and screening plant materials would be planted to protect privacy and preserve vistas in the urban areas. Landscape nodes would be developed where appropriate at street crossings and other highly visible segments of the channel. The intent of the esthetic treament program would be to make the flood control project blend into the local community and be esthetically acceptable to the local community.

Landscaping and Planting

12-03 The proposed landscaping along the channel would consist of both drought tolerant native plant species, and more formal non-native species depending on the surrounding environmental setting. Native and non-native plant material noted for diverse color and texture would be selected based on their compatibility with previously established plant communities in the adjacent local area. Typical plant species are presented in table XII-1. A more definitive plant list of native and non-native plant materials including trees, shrubs, and ground covers, will be developed subsequent to an on site evaluation and inventory of existing established communities. The landscape plantings selected for each reach will not only reflect visual and esthetic values, but will also be selected to provide soil and bank stabilization and erosion control. Irrigation systems of both a temporary and permanent type would be installed where required. Drip irrigation systems would be installed where appropriate to minimize water use and reduce vandalism and theft of equipment. More extensive and detailed irrigation systems would be installed throughout the greenbelt areas.

12-04 All landscape plantings would be within the flood control rights-of-way, and would be planted in such a way as not to impact the operation and safety of the flood control levees or features.

Table XII-1. Plant Species.

	Common Names	Scientific Names
TREES:		
	Fremont Cottonwood	Populus fremontii
	California Sycamore	Platanus racemosa
	White Alder	Alnus rhombifolia
	Black Cottonwood	Populus trichocarpa
	Black Willow	Salix gooddingii
	Sandbar Willow	Salix hindsiana
	Red Willow	Salix laevigata
	Arroyo Willow	Salix lasiolepis
	Mexican Elderberry	Sambucus mexicana

Table XII-1. (Continued)

Common Names	Scientific Names
TREES (Continued):	
Big Leaf Maple	Acer Macrophyllum
California Buckeye	Aesculus California
Palo Verde	Cercidium Floridum
Esertn Redbud	Cercis Occidentalis
Fremontia	Fremontia Californicum
California Walnut	Juglans California
Catalina Ironwood	Lyonothamnus Floribundus
Coastline Oak	Quercus Agrifolia
California Bay Laurel	Umbellularia Californica
SHRUBS:	
Mountain Mahogany	Cercocarpus betuloides
Common Buckwheat	Eriogonum fasciculatum
Deerweed	Lotus scoparius
California Sagebrush	Artemesia californica
Desert Encelia	Encelia californica
White Sage	Salvia apiana
Black Sage	Salvia mellifera
Dragon Sagewort	Artemesia dracunculus
Manzanita Louis Edmunds	Arctostaphylos Bakeri
Spice Bush	Calycanthus Occidentalis
California Lilac	Ceanothus "Concha"
California Lilac	Ceanothus "Ray Hartman"
Bush Poppy	Dendromecon Rigida
Coastal Buckwheat	Eriogonum Parviolium
Sulphur Flower	Eriogonum Umbellatum
Toyon	Heteromeles Arbutifolia
Tree Mallow	Lavatera Assurgentiflora
Nevins Mahonia	Mahonia Nevinil
Bush Monkey Flower	Mimulus Longiflorus
Red Monkey Flower	Mimulus Puniceus
California Scrub Oak	Quercus Dumosa
Coffee Berry	Rhamnus Californica
Laurel Sumac	Rhus Laurina
Fuchsia Flowering Gooseberry	Ribes Speciosum
Matilija Poppy	Romneya Coulteri
California Wild Rose	Rosa Californica
Woolly Blue Curls	Trichostema Lanatum
Foothill Yucca	Yucca Whippleii

Table XII-1. (Continued)

Common Names	Scientific Names
GROUNDCOVERS:	
Little Star Manzanita	Arctostaphylos Edmundsii
	Arctostaphylos Emerald Carpet
	Arctostaphylos Pacific Mist
	Arctostaphylos Point Reyes
Coyote Bush	Baccharis Pilularis
Point Reyes	Ceanothus Gloriosus
Maritime Ceanothus	Ceanothus Maritimus
Sea Dahlia	Coreopsis Maritimus
Chalk Dudleya	Dudleya Pulverulenta
	Eriogonum Species
Douglas Iris	Iris Douglasiana
Beach Evening Primrose	Oenothera Cheiranthifolia
"Prostrata"	Salvia Mellifera
Blue Eyed Grass	Sisyrinchium Bellum
Purple Needle Grass	Stipa Pulchra

A typical section of the proposed planting for the improved channel is shown on plate 90.

XIII. DIVERSION AND CONTROL OF WATER DURING CONSTRUCTION

General

13-01 Climatological information indicates that nearly all of the annual rainfall in the drainage area occurs during the rainy season between mid-October and mid-April, and the remainder of the year is considered the dry period. The wide channel invert permits diversion of flows to one side of the channel during construction. Most of the construction of the channel is expected to take place during the period between April and October. The existing Prado Dam could also be utilized to control runoff entering the construction area. Runoff from the local drainage area will be in small amounts and can be controlled by the construction of small dikes or bypass structures, and the installation of pumps. Shallow ground water will be encountered during construction of the channel. A localized mound of subsurface water, the result of perennial low flows in the channel, will be present at shallow depths throughout the construction area, and require dewatering prior to concrete or grouted stone construction. In general outside of tidal influenced reaches, ground water would be controlled by ditches and sumps through the construction area.

13-02 During the period of channel construction between April and October, the anticipated maximum streamflow is estimated to be less than 500 ft^3/sec.

Levee and Jetty Construction

13-03 Portions of the levee and jetty construction of the channel downstream from Fairview Channel will require construction below sea level. Dredging will be allowed for grading of the invert and the levee toe excavation. Dewatering is not considered necessary. Placement of stone underwater for levee construction will require an increase of 50 percent in the design layer thickness.

XIV. REAL ESTATE REQUIREMENTS

General

14-01 The recommended channel improvements would be constructed mostly within the existing rights-of-way or easements owned by local county agencies or the local flood control districts. However, additional rights-of-way would be required for channel widening, access ramps at street crossings, and access roads. Temporary easements would be needed during construction for detours, haul roads and disposal of surplus excavated materials, and contractor's work areas and storage yards. Construction of the proposed lower Santa Ana River Mainstem Channel will require a total of about 1,300 acres of permanent rights-of-way for channel construction and about 1,123 acres in fee for floodplain management in the Santa Ana Canyon between Prado Dam and Weir Canyon Road.

Acquisition

14-02 In accordance with the authorizing documents, the local sponsoring agency will be responsible for acquiring and bearing all costs in association with the acquisition of channel rights-of-way and construction easements. Acquisition of both rights-of-way and easements will be completed prior to the initiation of each reach of construction. In general, project rights-of-way will require fee acquisition where there is a structural improvement located within the right-of-way. Less than fee can be obtained when there are no present or future anticipated use or structural improvement intended. To preclude any future changes in land use, fee interest in the lands within the Santa Ana River Canyon is necessary, including all of the golf course properties.

LOWER SANTA ANA RIVER CHANNEL

Prado Dam to Weir Canyon

14-03 The upstream portion of the project from Prado Dam to Weir Canyon requires approximately 1,123 acres to be purchased in fee. It includes: (1) the Green River Golf Course, with its clubhouse, covering approxi-

mately 325 acres, and (2) Featherly Regional Park, a county park developed for recreational vehicles and camping uses with all the necessary facilities. In addition, there are several citrus groves scattered along the river bottom and within the area.

The estimated cost of real estate for this project reach is:

Land	$ 9,991,000
Improvements	7,225,000
Damages	1,721,000
Contingencies (20%)	3,787,000
Relocations (PL 91-646)	100,000
Administrative Costs	1,915,000
Total Costs	$24,739,000

Weir Canyon to Victoria Street

14-04 The central portion of the project downstream from Weir Canyon to just south of Victoria Street requires approximately 72 acres outside of the channel and 1,225 acres within the channel to be taken in fee. The largest single area is the River View Golf Course, an existing 9 hole course situated within the river bottom covering approximately 42 acres. The balance of the acreage consists of several narrow strips of land where the levee will be moved to provide a wider channel. One of the narrow strips of land along the Mesa Verda Country Club contains a screen of large mature trees. Some modification of one tee and the irrigation system will be necessary after the acquisition of this strip.

The estimated cost of real estate in this portion is:

Land	$2,735,000
Improvements	1,600,000
Damages	433,500
Contingencies (20%)	953,700
Relocations (PL 91-646)	20,000
Administrative Costs	280,000
Total Costs	$6,022,200

14-05 The southern portion of the channel from Victoria Street to the Pacific Coast Highway includes a narrow strip of land for widening the river channel. This land is owned by West Newport Oil Company and the City of Newport and is within the West Newport oil field. There are two operating wells in the strip which will be relocated. The two operating wells will be abandoned as well as two other non-operating wells.

The estimated real estate cost of the 9.5± acres is:

Land	$ 712,000
Relocation of Wells (2)	524,000
Abandonment of Wells (4)	81,000
Contingencies	263,000
Administrative Costs	30,000
Total Costs	$1,610,000

SUMMARY OF REAL ESTATE COSTS SANTA ANA RIVER CHANNEL

14-06 The total of all real estate costs for channel construction from Prado Dam to the Pacific Ocean is:

Land	$13,438,000
Improvements	8,825,000
Damages	2,154,500
Relocation of Wells	524,000
Abandonment of Wells	81,000
Contingencies (20%)	5,003,700
Relocations	120,000
Administrative Costs	2,225,000
Total Costs	$32,371,200

MARSH RESTORATION AREA

14-07 The Santa Ana River Flood Control Project includes the purchase of 92 acres of degraded wetlands at the mouth of the river for restoration as a salt marsh. Acquisition for eight of the 92 acres are for mitigation purposes and is the responsibility of the local sponsor. The land is owned by West Newport Oil Company and the City of Newport. A schematic plan of the marsh is shown in figure XIV-1.

Within the 92 acres there are three wells in which the City of Newport has a 100 percent working interest. These are to be retained by the city with an easement interest in approximately 3 acres of land for continued operation of the wells. Two other wells are within the proposed restoration area to be relocated and 12 wells are to be abandoned.

The estimated real estate cost of the 92 acres is:

Land*	$6,787,000
Relocation of Wells	524,000
Abandonment of Wells	221,000
Contingencies (20%)	1,506,000
Administrative Costs	265,000
Total Costs	$9,303,000

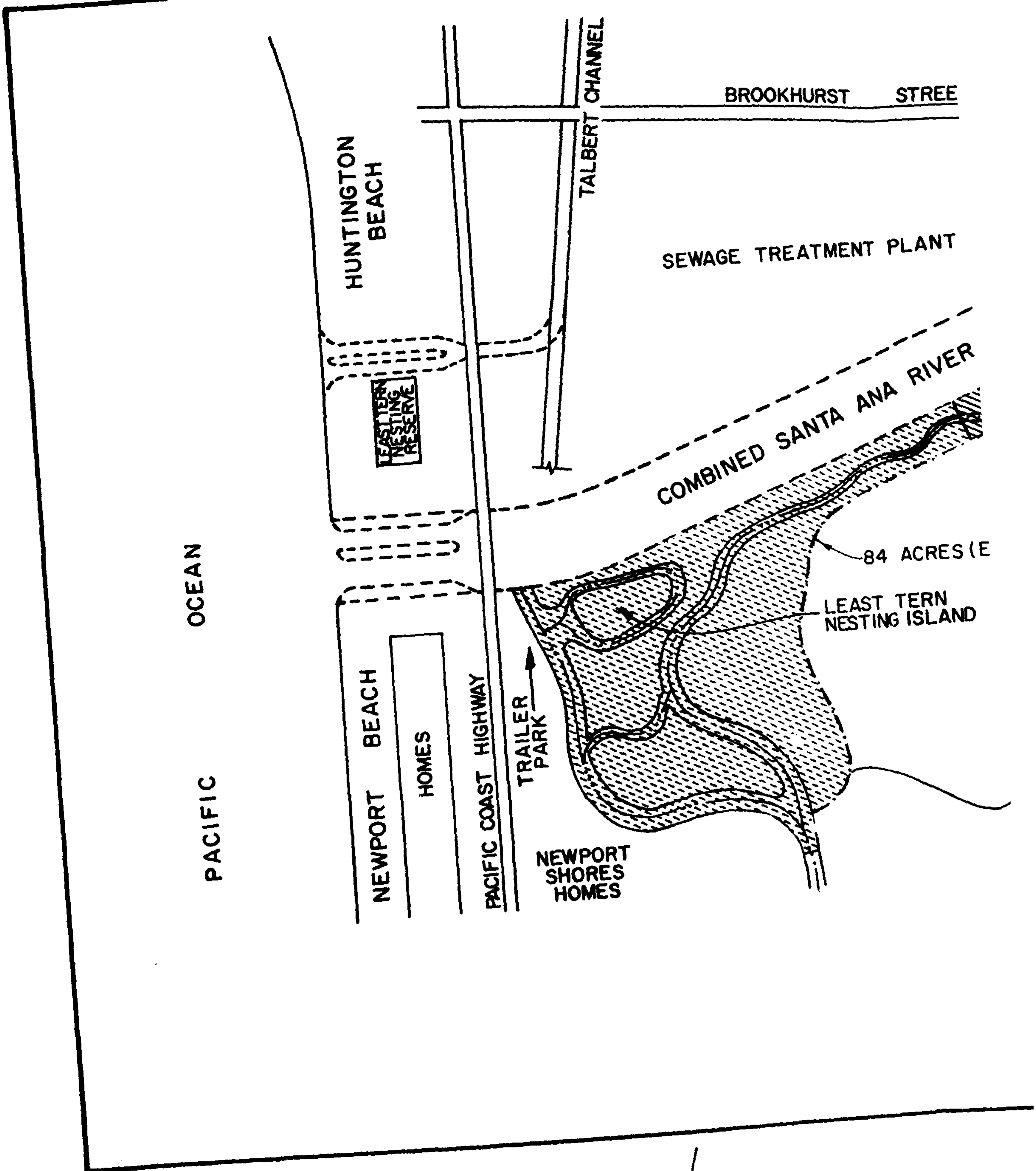
*Includes 8 acres of mitigation land.

14-08 Land acquisition costs for Phase I and Phase II plans are compared below:

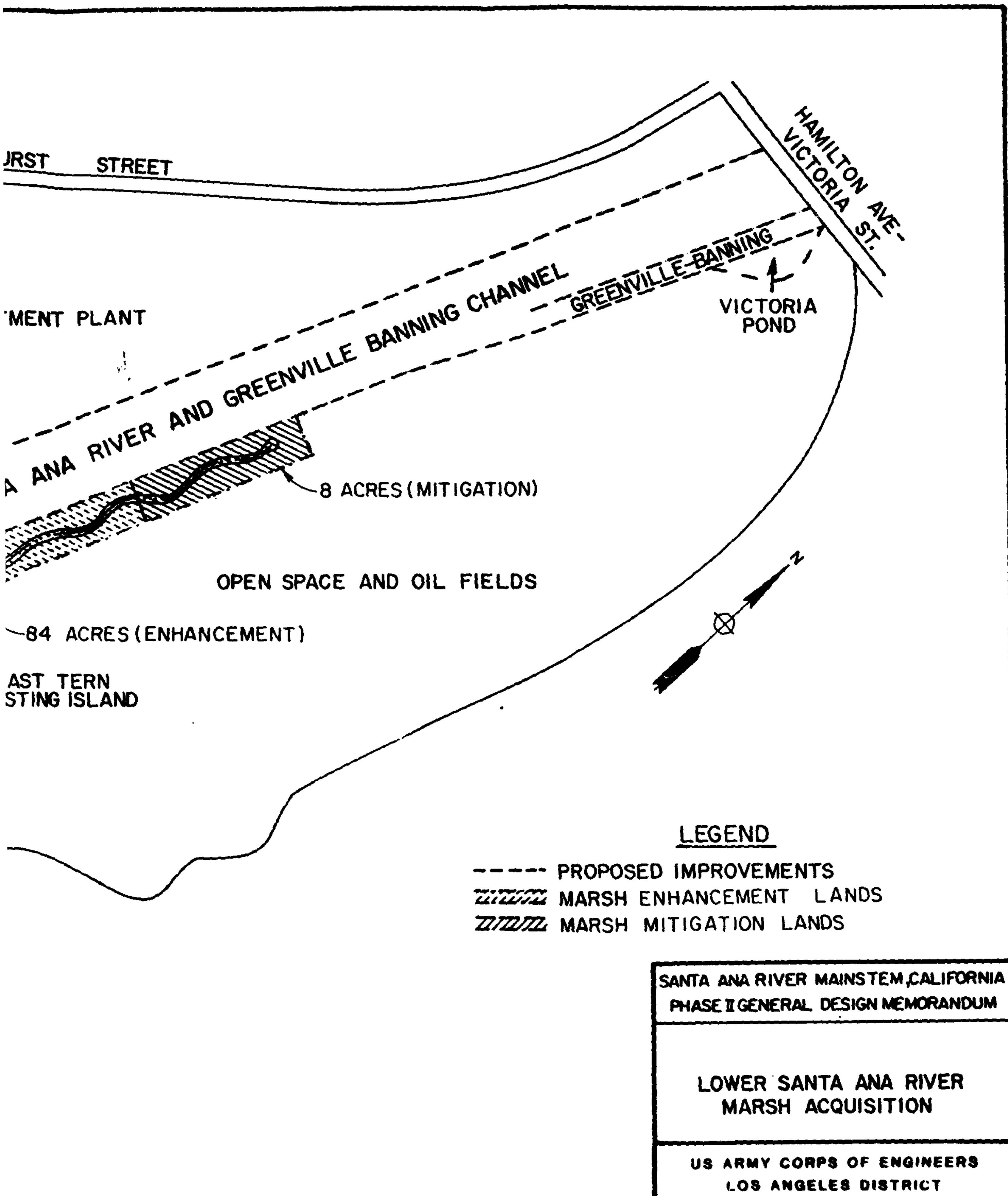
Location	Phase I GDM	Present	Difference
Santa Ana Canyon	$13,000,000	$24,739,000	+$11,739,000
Urban Reach	6,040,000	7,632,200	+ 1,592,200
Marsh Restoration	4,220,000	9,303,000	+ 5,083,000
TOTAL DIFFERENCES			+$18,414,200

The major differences in cost is attributed to inflation, and a more definitive rights-of-way requirement.

Figure XIV-1. Lower Santa Ana River Marsh Acquisition.



BROOKHURST STREE
TALBERT CHANNEL
HUNTINGTON BEACH
SEWAGE TREATMENT PLANT
LEAST TERN NESTING RESERVE
COMBINED SANTA ANA RIVER
84 ACRES (E
LEAST TERN NESTING ISLAND
PACIFIC OCEAN
NEWPORT BEACH
HOMES
PACIFIC COAST HIGHWAY
TRAILER PARK
NEWPORT SHORES HOMES



JRST STREET
HAMILTON AVE-
VICTORIA ST.
'MENT PLANT
A ANA RIVER AND GREENVILLE BANNING CHANNEL
GREENVILLE-BANNING
VICTORIA
POND
8 ACRES (MITIGATION)
OPEN SPACE AND OIL FIELDS
84 ACRES (ENHANCEMENT)
AST TERN
STING ISLAND
N
LEGEND
PROPOSED IMPROVEMENTS
MARSH ENHANCEMENT LANDS
MARSH MITIGATION LANDS
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER
MARSH ACQUISITION
US ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

FIGURE XIV-1

XV. COST ESTIMATES

First Costs

15-01 The total first cost of the proposed Santa Ana River Channel is presently estimated at $365,000,000 which includes a pre-construction engineering and design cost of $10,550,000. The unit price for various items of work was based on the recent construction bid prices in southern California. In accordance with EM 1110-2-1301, a 15 percent contingency is added to the estimated construction cost. Seven percent and six percent of construction cost were selected for the cost for engineering and design, and supervision and administration, respectively. These percentages are based on the present actual prevailing rates experienced by the Los Angeles District Office. The costs reflected for construction easements, bridge relocations and modifications and relocation of utilities are estimated costs. Final costs may vary. The overall costs are identified for ten project reaches and the marsh restoration (table XV-1). The limits of the reaches were selected based on the type of channel being constructed, the length of each project reach, the estimated time and cost for construction of each reach. The selection of a combination of one or more reaches for construction purposes is also feasible. First costs of each reach and of the total project are shown in tables XV-2 through XV-16.

Comparison of Estimates

15-02 A comparison of Phase I estimated project costs (October 1979 price levels), the updated Phase I GDM (October 1987 price levels) and the present cost estimate is shown in table XV-4. The main reason for the variation between the Phase I and updated Phase I GDM estimates is a 46 percent price level increase in construction cost as indicated by the price level indexes between October 1979 and October 1987. The major reasons for the differences between the updated Phase I GDM cost estimate and the recommended plan are presented in the following paragraphs.

a. Eliminating the need to reconstruct two railroad bridges, trackage and shooflies resulted in the decrease of $19,000,000 of project cost.

b. The downstream end of the project from the mouth of the river to 2.5 miles upstream was changed from a vertical concrete wall channel to a trapezoidal riprap channel. The change resulted in a decrease in project cost of about $12,000,000.

c. An addition of $5,000,000 for the removal of the existing channel and jetty structure is due to the widening for the new channel and concrete and grouted stone removal which were not included in the Phase I estimate.

d. The decrease of $5,300,000 in the cost of channel earthwork is due to the reduction in channel excavation and disposal of excess material quantities as a result of the final channel design.

e. Based on Los Angeles District's cost index for engineering and design, a decrease of $4,500,000 in engineering and design, and $4,000,000 in supervision and administration are the result of in overall decrease in construction cost.

f. Inclusion of the cost for the preparation of Operation and Maintenance Manual increases the project first cost by $130,000.

g. The increase in cost of $18,000,000 for lands and damages is due to a more recent and detailed appraisal. The price increase in the Santa Ana Canyon is attributed to a more realistic value for taking a fee interest for the Green River Golf Course and for acquisition of the marsh land at the river mouth, including the cost of discontinuing oil operations and the abandonment and relocation of existing wells.

h. The estimated construction cost for highways and bridges decreasing by $14,500,000 is attributed to modifying the piers and footings of nine bridges instead of total reconstruction.

i. The increase of $1,700,000 in the estimated cost for relocation of utilities is due to the more detailed information and the recent Policy Guidance, Letter No. 5, for "New Start Construction Projects", E.C. 1165-2-144, dated June 1, 1987. Utilities relocations would have normally been a local responsibility and cost.

j. A decrease in the amount of $5,000,000 in the cost of channel revetment was made as a result of more detailed design. Due to more intensive design details, a decrease in the amount of $31,000,000 in the total overall cost is attributed to the difference in contingencies for the Phase I estimate and the Phase II estimate.

k. An increase of about $7,500,000 is due to pre-construction engineering and design cost already expended to date.

l. Changes in design or construction methods are the reasons for the remaining differences.

Table XV-1. Lower Santa Ana River Channel Reaches for Cost Estimate.

NO.	REACH	REMARKS
1.	Pacific Ocean to Fairview Channel (stations 7+60 to 150+32) including Marsh Restoration	Soft Bottom R.R. Trap. Grading & Planting
2.	Fairview Channel to San Diego Freeway (stations 150+32 to 273+00)	Rectangular Concrete
3.	San Diego Freeway to Edinger Avenue (stations 273+00 to 393+50)	Concrete Trap.
4.	Edinger Avenue to River View Golf Course (Inlet) (stations 393+50 to 535+80)	Concrete Trap.
5.	River View Golf Course (Inlet) to Orange Freeway (stations 535+80 to 689+85)	Soft Bottom R.R. Trap.
6.	Orange Freeway to Glassell Street (stations 689+85 to 865+15)	Soft Bottom R.R. Trap.
7.	Glassel Street to Imperial Highway (stations 865+15 to 1069+10)	Soft Bottom R.R. Trap.
8.	Imperial Highway to Weir Canyon Road (Inlet) (stations 1069+10 to 1218+20)	Soft Bottom R.R. Trap.
9.	Weir Canyon Road (Inlet) Corona Freeway (Prado Dam) (stations 1218+20 to 1607+50)	Levee Protection
10.	Greenville-Banning Channel (stations 9+50 to 177+00)	Concrete Rect. & Trap.

Table XV-2. Santa Ana River Mainstem Summary of First Cost by Reaches.

(October 1987 Price Levels)

Description	Totals
Reach 1 Pacific Ocean to Fairview Channel	$55,839,000
Reach 2 Fairview Channel to San Diego Freeway	69,475,000
Reach 3 San Diego Freeway to Edinger Avenue	27,365,000
Reach 4 Edinger Avenue to River View Golf Course	31,982,000
Reach 5 River View Golf Course to Orange Freeway	25,798,000
Reach 6 Orange Freeway to Glassel Street	29,700,000
Reach 7 Glassel Street to Imperial Highway	31,987,000
Reach 8 Imperial Highway to Weir Canyon Road	28,014,000
Reach 9 Weir Canyon Road to Corona Freeway	27,767,000
Reach 10 Greenville-Banning Channel	23,340,000
Fish and Wildlife Enhancement & Restoration	13,733,000
TOTAL FIRST COST	$365,000,000

Table XV-3. Santa Ana River Mainstem
Summary of Contract Reaches

(October 1987 Price Level)
Totals x 1000

Cost Code	Feature Items	Reach 1 & 10	Reach 2	Reach 3 & 4	Reach 5 & 6	Reach 7 & 8	Reach 9	Marsh	Totals
01	F&WL enhancement lands							7,258	$7,258
02	Relocations	550	326	146	1,310	148		947	3,427
06	F&WL enhancement							4,623	4,623
09	Channel	53,104	58,878	47,263	37,099	49,071	1,630		247,045
14	Recreation						600		600
30	Engineering and design	1,016	4,023	3,221	2,609	3,343	111		14,323
31	Supervision & administration	3,118	3,556	2,882	2,312	2,956	96	333	15,253
51.22	O&M manual	20	10	20	20	20	10	30	130
	Total construction	$57,808	$66,793	$53,532	$43,350	$55,538	$2,447	$13,191	$292,659
	Mitigation lands	691							691
	Lands and Damages	5,920	600	1,200	1,500	1,700	24,739		35,659
	Relocations	10,415	630	3,381	9,486	1,529	0		25,441
	Total LERRD cost	17,026	1,230	4,581	10,986	3,229	24,739		61,791
	Total	$74,834	$68,023	$58,113	$54,336	$58,767	$27,186	$13,191	$354,450
	Preconstruction E&D	4,345	1,452	1,234	1,162	1,234	581	542	10,550
	Total First Cost	$79,179	$69,475	$59,347	$55,498	$60,001	$27,767	$13,733	$365,000

Table XV-4. Santa Ana River Mainstem
Comparison of First Cost

Cost Acct No.	Description	Phase I Oct 79 Price Level	Phase I GDM Estimate Oct 87 Price Level	Present Estimate Oct 87 Price Level
	Construction:			
02	Relocations:			
	Utilities			$1,632,800
	Construction and railroad modification costs			
	Railroad shoofly	$5,641,000	$8,393,200	
	Railroad bridges	7,521,000	11,190,000	523,000
09	Channel:			
	Diversion & control of water	1,283,000	1,908,844	1,097,000
	Clear and grub	979,000	1,456,554	775,000
	Stone removal	6,968,000	10,366,974	10,154,000
	Concrete removal	3,010,000	4,478,271	4,795,000
	Stabilizers	0	0	6,255,000
	Remove exist. jetties and channel structure	0	0	3,845,000
	Jetties	0	0	1,489,000
	Levee spillway	0	0	6,875,000
	Sheet pile	0	0	138,000
	Earthwork			
	Channel excavation	28,123,000	41,841,333	16,212,000
	Toe excavation	3,477,000	5,173,072	1,743,700
	Disposal, excess mat'l	0	0	15,642,800
	Foundation treatment	0	0	600,000
	Subgrade preparation	115,000	171,097	
	Levee fill	16,000	23,805	4,615,000
	Channel wall fill	4,400,000	6,546,309	3,890,000
	Toe backfill	1,059,000	1,575,578	1,659,000
	Misc. fill	389,000	578,753	283,200
	Grout	250,000	371,949	6,634,000
	Stone levee	14,490,000	21,558,187	14,842,000
	Filter levee	4,455,000	6,628,138	2,265,600
	Filter fabric	0	0	30,000
	Borrow	0	0	364,000
	Concrete			
	Wall	9,880,000	14,699,440	6,600,000
	Footing and invert	20,629,000	30,691,776	25,610,000
	Cutoff wall	7,828,000	11,646,479	0
	Concrete, slope	0	0	5,491,500
	Cement	19,398,000	28,860,298	15,905,700
	Rein. steel	19,418,000	28,890,053	17,770,950

Table XV-4. (Continued)

Cost Acct No.	Description	Phase I Oct 79 Price Level	Phase I GDM Estimate Oct 87 Price Level	Present Estimate Oct 87 Price Level
	Scour gages	$0	$0	$75,000
	Subdrain system	6,965,000	10,362,510	10,825,000
	Santiago bridge	0	0	101,000
	Bitterbush bridge	0	0	112,000
	Carbon Canyon bridge	0	0	150,000
	Side drain	780,000	1,160,482	5,451,000
	A.C. paving	994,000	1,478,871	1,647,450
	Retaining wall	0	0	1,670,000
	Fencing	762,000	1,133,702	2,366,800
	Drop structure	2,285,000	3,399,617	9,630,000
	Detention ponds and siphon	0	0	427,500
	Esthetic treatment	2,309,000	3,435,325	5,880,000
	Erosion control	0	0	100,000
	Bridge Over Greenville-Banning Channel	286,000	425,510	0
	Subtotal	$173,710,000	$258,446,127	$216,174,000
	Contingencies	43,428,000	64,611,873	33,351,000
	Subtotal channel	$217,138,000	$323,058,000	$249,525,000
30	Engineering and design	21,714,000	29,414,000	14,323,000
31	Supervision and administration	15,200,000	19,315,000	14,920,000
51.22	O & M manual		0	100,000
	Total construction	$254,052,000	$371,787,000	$278,868,000
	Lands And Damages			
	Lands	19,040,000	28,327,000	35,659,000
	R/W mitigation	365,000	543,000	691,000
	Subtotal R/W costs	$19,405,000	$28,870,000	$36,350,000
	Relocations			
	Oil wells	0	0	1,100,000
	Victoria pond	0	0	150,000
	Talbert Channel	0	0	4,900,000
	Roads and bridges	21,376,000	31,803,000	17,363,000
	Utilities	1,447,000	2,153,000	458,000
	Recreation	0	0	1,470,000
	Subtotal relocations	$22,823,000	$33,956,000	$25,441,000
	Total lands and relocations	$42,228,000	$62,826,000	$61,791,000
	Preconstruction Engr. & Design			9,996,000
	Total	$296,280,000	$434,613,000	$350,655,000

Table XV-4. (Continued)

Cost Acct No.	Description	Phase I Oct 79 Price Level	Phase I GDM Estimate Oct 87 Price Level	Present Estimate Oct 87 Price Level
14	Recreation:			
	Recreation facilities	$550,000	$819,000	$462,000
	Contingencies	83,000	123,000	70,000
	Total	$633,000	$942,000	$532,000
	Engineering & design	63,000	85,000	36,000
	Supervision & administration	44,000	56,000	32,000
	Total, recreation	$740,000	$1,083,000	$600,000
	Preconstruction Engr. & Design			12,000
	Total	$740,000	$1,083,000	$612,000
	Total, Project First Cost	$297,020,000	$435,696,000	$351,267,000
	Fish and Wildlife Enhancement:			
01	Fish and wildlife enhancement lands			7,258,000
02	Relocations:			
	Abandon wells			210,700
	Relocate wells			500,000
	Abandon power poles			32,000
	Utilities			81,000
06	Fish and wildlife enhancement			4,021,077
	Subtotal			4,844,777
	Contingencies			725,223
	Subtotal channel			5,570,000
	Engineering and design			0
	Supervision and administration			333,000
	O&M manual			30,000
	Total construction			5,933,000
	Total	$3,855,000	$5,735,000	$13,191,000
	Preconstruction E&D			542,000
	Total, Project First Cost	$3,855,000	$5,735,000	$13,733,000

Table XV-5. Santa Ana River Mainstem
Detailed Summary of First Cost

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Total
01	Fish and wildlife enhancement lands..					$7,258,000
	Construction:					
02	Relocations:					
	Abandon wells...........	1	Job	LS	$210,700	
	Relocate wells..........	1	Job	LS	500,000	
	Abandon power poles.....	16	Ea	2,000.00	32,000	
	Utilities	1	Job	LS	1,713,800	
	Modify OCRTD Bridge.....	1	Job	LS	73,000	
	Modify SPRR Bridge......	1	Job	LS	200,000	
	Modify AT&SF RR Bridge..	1	Job	LS	150,000	
	Modify SPRR Bridge......	1	Job	LS	100,000	
06	Fish and wildlife enhancement...............	1	Job	LS	4,021,077	
09	Channel:					
	Diversion & control of water................	1	Job	LS	1,097,000	
	Concrete removal........	1	Job	LS	1,506,000	
	Clearing & grubbing.....	1	Job	LS	775,000	
	Remove stone............	1	Job	LS	1,514,000	
	Excavation channel......	6,755,000	CY	2.40	16,212,000	
	Excavation toe..........	742,000	CY	2.35	1,743,700	
	Foundation Treatment....	1	Job	LS	600,000	
	Miscellaneous fill......	24,000	CY	1.05	25,200	
	Miscellaneous fill......	172,000	CY	1.50	258,000	
	Compacted fill, wall....	778,000	CY	5.00	3,890,000	
	Compacted fill..........	1,846,000	CY	2.50	4,615,000	
	Toe fill................	553,000	CY	3.00	1,659,000	
	Borrow..................	182,000	CY	2.00	364,000	
	Stone work					
	12" stone layer.......	12,200	CY	29.00	353,800	
	12" stone layer.......	8,300	CY	30.00	249,000	
	15" stone layer.......	182,000	CY	26.00	4,732,000	
	15" stone layer.......	180,000	CY	29.00	5,220,000	
	18" stone layer.......	44,800	CY	29.00	1,299,200	
	21" stone layer.......	37,000	CY	29.00	1,073,000	
	21" stone layer.......	33,500	CY	30.00	1,005,000	
	24" stone layer.......	17,000	CY	29.00	493,000	
	36" stone layer.......	9,500	CY	30.00	285,000	
	48" stone layer.......	4,400	CY	30.00	132,000	

Table XV-5. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Total
	Grout.................	132,680	CY	$50.00	$6,634,000	
	Bedding...............	94,400	CY	24.00	2,265,600	
	Filter fabric.........	15,000	CY	2.00	30,000	
	Stabilizers............	1	Job	LS	6,255,000	
	Stone removal...........	720,000	Ton	12.00	8,640,000	
	Concrete removal........	59,800	CY	55.00	3,289,000	
	Concrete, invert........	269,500	CY	70.00	18,865,000	
	Concrete, footing.......	71,000	CY	95.00	6,745,000	
	Concrete, wall..........	60,000	CY	110.00	6,600,000	
	Concrete, slopes........	52,300	CY	105.00	5,491,500	
	Portland Cement.........	3,534,600	Cwt	4.50	15,905,700	
	Steel reinforcement.....	39,491,000	Lbs	0.45	17,770,950	
	Scour gages.............	150	Ea	500.00	75,000	
	Disposal, Excess Mat'l..	2,769,000	CY	4.50	12,460,500	
	Disposal, Excess Mat'l..	339,000	CY	3.25	1,101,750	
	Disposal, Excess Mat'l..	143,000	CY	2.75	393,250	
	Disposal, Excess Mat'l..	260,000	CY	2.45	637,000	
	Disposal, Excess Mat'l..	558,000	CY	1.50	837,000	
	Disposal, Excess Mat'l..	237,000	CY	0.90	213,300	
	Remove exist. jetties and channel structure...	1	Job	LS	3,845,000	
	Jetties.................	1	Job	LS	1,489,000	
	Drop structure..........	1	Job	LS	3,860,000	
	Modify existing drop structure..........	1	Job	LS	5,770,000	
	Levee spillway..........	1	Job	LS	6,875,000	
	Sheet pile.............	4,600	SF	30.00	138,000	
	Asphalt concrete pavement................	36,610	Ton	45.00	1,647,450	
	Retaining wall..........	1	Job	LS	1,670,000	
	Fencing, channel wall...	1	Job	6.00	294,000	
	Fencing, right-of-way...	259,100	LF	8.00	2,072,800	
	Santiago bridge.........	1	Job	LS	101,000	
	Bitterbush bridge.......	1	Job	LS	112,000	
	Carbon Canyon bridge....	1	Job	LS	150,000	
	Side drains.............	1	Job	LS	5,451,000	
	Subdrainage............	1	Job	LS	10,825,000	
	Esthetic treatment......	1	Job	LS	5,880,000	
	Detention ponds & siphon..................	1	Job	LS	427,500	
	Erosion control.........	1	Job	LS	100,000	
	Subtotals, channel..............................				$221,018,777	
	Contingencies...					34,076,223

Table XV-5. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
30	Engineering & design					$14,323,000
31	Supervision & administration					15,253,000
51.22	O&M Manual					130,000
	Total, construction					$284,801,000
	Lands & relocations:					
	Lands & damages					35,659,000
	R/W mitigation					691,000
	Relocations:					
	Abandon and relocate oil wells				$1,100,000	
	Utilities				458,000	
	Victoria Pond				150,000	
	Bridges				17,363,000	
	Talbert Channel				4,900,000	
	Recreation				1,470,000	
	Total, relocations					$25,441,000
	Total, lands & relocations					$61,791,000
	Total Santa Ana River Mainstem					$353,850,000
	RECREATION					
	Construction:					
14	Recreation facilites:					
	Total, recreation facilities					$600,000
	Total					$354,450,000
	Preconstruction engineering & design					10,550,000
	Total First Cost					$365,000,000

Table XV-6 Santa Ana River Mainstem, Reach 1
Detailed Estimate of First Cost
Pacific Ocean to Fairview Channel
(Stations 7+60 to 150+32)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	FLOOD CONTROL					
	Construction:					
02	Relocation:					
	Utilities..............	1	Job	LS	$478,000	
09	Channel:					
	Diversion & control of water.................	1	Job	LS	337,000	
	Concrete removal.........	1	Job	LS	1,506,000	
	Clearing & grubbing......	1	Job	LS	100,000	
	Remove stone.............	1	Job	LS	1,514,000	
	Excavation channel.......	1,810,000	CY	$2.40	4,344,000	
	Excavation toe...........	225,000	CY	2.35	528,750	
	Compacted fill...........	473,000	CY	2.50	1,182,500	
	Toe fill.................	160,000	CY	3.00	480,000	
	Disposal, excess mat'l...	1,402,000	CY	4.50	6,309,000	
	Stone work					
	12" stone layer........	12,200	CY	29.00	353,800	
	15" stone layer........	67,000	CY	29.00	1,943,000	
	18" stone layer........	18,800	CY	29.00	545,200	
	21" stone layer........	33,500	CY	30.00	1,005,000	
	36" stone layer........	3,500	CY	30.00	105,000	
	48" stone layer........	4,400	CY	30.00	132,000	
	Bedding................	69,400	CY	24.00	1,665,600	
	Filter fabric..........	15,000	SY	2.00	30,000	
	Stabilizer.............	1	Job	LS	251,000	
	Remove exist. jetties and channel structure..	1	Job	LS	3,845,000	
	Jetties................	1	Job	LS	1,489,000	
	Asphalt concrete pavement..............	3,500	Ton	45.00	157,500	
	Retaining wall.........	1	Job	LS	930,000	
	Fencing, right-of-way..	28,500	LF	8.00	228,000	
	Side drains............	1	Job	LS	143,000	
	Esthetic treatment.....	1	Job	LS	168,000	
	Subtotal, channel..............................				$29,770,350	
	Contingencies..................................				5,283,650	
	Total, channel..					$35,054,000

Table XV-6. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
30	Engineering & design					$664,000
31	Supervision & administration					2,006,000
51.22	O&M Manual					10,000
	Total, construction					$37,734,000
	Lands & relocations:					
	Lands & damages				$2,310,000	
	Talbert lands				2,000,000	
	Mitigation				691,000	
	Total lands					$5,001,000
	Relocations:					
	Abandon & relocate oil wells				1,100,000	
	Bridges				3,605,000	
	Utilities				29,000	
	Recreation				631,000	
	Talbert channel				4,900,000	
	Total, relocations					$10,265,000
	Total, lands & relocations					$15,266,000
	Total					$53,000,000
	Preconstruction engineering & design					2,839,000
	Total project cost Santa Ana River Mainstem, Reach 1					$55,839,000

Table XV-7. Santa Ana River Mainstem, Reach 2
Detailed Estimate of First Cost
Fairview Channel to San Diego Freeway
(Stations 150+32 to 273+00)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Total
	FLOOD CONTROL					
	Construction:					
02	Relocation:					
	Utilities.............	1	Job	LS	$283,400	
09	Channel:					
	Diversion & control of water...............	1	Job	LS	100,000	
	Clearing & grubbing....	1	Job	LS	100,000	
	Excavation channel.....	1,825,000	CY	$2.40	4,380,000	
	Compacted fill, wall...	458,000	CY	5.00	2,290,000	
	Foundation treatment...	1	Job	LS	200,000	
	Disposal, excess mat'l.	1,367,000	CY	4.50	6,151,500	
	Stone removal..........	73,000	Ton	12.00	876,000	
	Concrete removal.......	17,500	CY	55.00	962,500	
	Concrete, invert.......	111,500	CY	70.00	7,805,000	
	Concrete, footing......	45,000	CY	95.00	4,275,000	
	Concrete, wall.........	38,000	CY	110.00	4,180,000	
	Portland cement........	1,092,000	CWT	4.50	4,914,000	
	Steel reinforcement....	18,771,000	Lbs	0.45	8,446,950	
	Stabilizer, invert.....	1	Job	LS	1,030,000	
	Asphalt concrete pavement..............	4,000	Ton	45.00	180,000	
	Retaining wall.........	1	Job	LS	740,000	
	Fencing, channel.......	25,000	LF	6.00	150,000	
	Fencing, right-of-way..	25,000	LF	8.00	200,000	
	Side drains............	1	Job	LS	58,000	
	Subdrainage System.....	1	Job	LS	3,700,000	
	Esthetic treatment.....	1	Job	LS	424,000	
	Erosion control........	1	Job	LS	50,000	
	Subtotal, channel..............................				$51,496,350	
	Contingencies..................................				7,707,650	
	Total, channel..					$59,204,000
30	Engineering & design..					4,023,000
31	Supervision & administration...................................					3,556,000
51.22	O&M Manual..					10,000
	Total, construction..					$66,793,000

Table XV-7. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	Lands & relocations:					
	Lands & damages					$600,000
	Relocations:					
	Bridges				$600,000	
	Recreation				30,000	
	Total, relocations					$630,000
	Total, lands & relocations					$1,230,000
	Total					$68,023,000
	Preconstruction engineering & design					1,452,000
	Total project cost, Santa Ana River Mainstem, Reach 2					$69,475,000

Table XV-8. Santa Ana River Mainstem, Reach 3
Detailed Estimate of First Cost
San Diego Freeway to Edinger Avenue
(Stations 273+00 to 393+50)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Total
	FLOOD CONTROL					
	Construction:					
02	Relocation:					
	Utilities..............	1	Job	LS	$54,000	
09	Channel:					
	Diversion & control of water...............	1	Job	LS	100,000	
	Clearing & grubbing....	1	Job	LS	100,000	
	Excavation channel.....	395,000	CY	$2.40	948,000	
	Compacted fill.........	47,000	CY	2.50	117,500	
	Disposal, excess mat'l.	339,000	CY	3.25	1,101,750	
	Miscellaneous fill.....	9,000	CY	1.05	9,450	
	Foundation treatment...	1	Job	LS	200,000	
	Concrete removal.......	20,000	CY	55.00	1,100,000	
	Concrete, invert.......	62,000	CY	70.00	4,340,000	
	Concrete, slopes.......	24,000	CY	105.00	2,520,000	
	Portland cement........	479,000	CWT	4.50	2,155,500	
	Steel reinforcement....	6,110,000	Lbs	0.45	2,749,500	
	Asphalt concrete pavement...............	2,500	Ton	45.00	112,500	
	Fencing, right-of-way..	24,500	LF	8.00	196,000	
	Side drains............	1	Job	LS	65,000	
	Subdrainage system.....	1	Job	LS	3,000,000	
	Esthetic treatment.....	1	Job	LS	224,000	
	Erosion control........	1	Job	LS	50,000	
	Subtotal, channel..............................				$19,143,200	
	Contingencies..................................				2,860,800	
	Total, channel..					$22,004,000
30	Engineering & design..					1,495,000
31	Supervision & administration....................................					1,360,000
51.22	O&M Manual..					10,000
	Total, construction...					$24,869,000
	Lands & relocations:					
	Lands & damages...					600,000
	Relocations:					
	Roads & bridges................................				1,295,000	

Table XV-8. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	Recreation				$28,000	
	Total, relocations					$1,323,000
	Total, lands & relocations					$1,923,000
	Total					$26,792,000
	Preconstruction engineering & design					573,000
	Total project cost, Santa Ana River Mainstem, Reach 3					$27,365,000

Table XV-9. Santa Ana River Mainstem, Reach 4
Detailed Estimate of First Cost
Edinger Avenue to River View Golf Course
(Stations 393+50 to 535+80)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	FLOOD CONTROL					
	Construction:					
02	Relocation:					
	Remodel OCRTD Bridge...	1	Job	LS	$73,000	
09	Channel:					
	Diversion & control of water...............	1	Job	LS	100,000	
	Clearing & grubbing....	1	Job	LS	100,000	
	Excavation channel.....	370,000	CY	$2.40	888,000	
	Compacted fill.........	95,000	CY	2.50	237,500	
	Disposal excess mat'l..	260,000	CY	2.45	637,000	
	Miscellaneous fill.....	15,000	CY	1.05	15,750	
	Foundation treatment...	1	Job	LS	200,000	
	Removal concrete.......	22,000	CY	55.00	1,210,000	
	Concrete, invert.......	82,000	CY	70.00	5,740,000	
	Concrete, side slope...	24,100	CY	105.00	2,530,500	
	Portland cement........	600,000	CWT	4.50	2,700,000	
	Steel reinforcement....	7,510,000	Lbs	0.45	3,379,500	
	Asphalt concrete pavement...............	2,800	Ton	45.00	126,000	
	Fencing, right-of-way..	29,000	LF	8.00	232,000	
	Side drains............	1	Job	LS	332,000	
	Subdrainage system.....	1	Job	LS	3,000,000	
	Esthetic treatment.....	1	Job	LS	614,000	
	Subtotal, channel..............................				$22,115,250	
	Contingencies..................................				3,289,750	
	Total, channel..					$25,405,000
30	Engineering & design..					1,726,000
31	Supervision & administration..................................					1,522,000
51.22	O&M Manual..					10,000
	Total, construction...					$28,663,000
	Lands & relocations:					
	Lands & damages...					600,000
	Relocations:					
	Utilities..................................				224,000	
	Bridges....................................				1,348,000	

Table XV-9. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	Recreation (includes bike bridge).............				$486,000	
	Total, relocations....................................					$2,058,000
	Total, lands & relocations...............................					$2,658,000
	Total..					$1,321,000
	Preconstruction engineering & design..........................					661,000
	Total project cost, Santa Ana River Mainstem, Reach 4............................					$31,982,000

Table XV-10. Santa Ana River Mainstem, Reach 5
Detailed Estimate of First Cost
River View Golf Course to Orange Freeway
(Stations 535+80 to 689+85)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Total
	FLOOD CONTROL					
	Construction:					
02	Relocation:					
	Modify SPRR Bridge.......	1	Job	LS	$200,000	
	Utilities................	1	Job	LS	415,300	
09	Channel:					
	Diversion & control of water...............	1	Job	LS	100,000	
	Clearing & grubbing....	1	Job	LS	100,000	
	Excavation channel.....	371,000	CY	$2.40	890,400	
	Excavation toe.........	120,000	CY	2.35	282,000	
	Compacted fill.........	552,000	CY	2.50	1,380,000	
	Toe fill...............	91,000	CY	3.00	273,000	
	Borrow.................	152,000	CY	2.00	304,000	
	Stone work					
	15" stone layer......	48,000	CY	29.00	1,392,000	
	18" stone layer......	26,000	CY	29.00	754,000	
	21" stone layer......	19,000	CY	29.00	551,000	
	Grout................	21,400	CY	50.00	1,070,000	
	Bedding..............	25,000	CY	24.00	600,000	
	Removal stone..........	38,000	Ton	12.00	456,000	
	Portland cement........	161,000	CWT	4.50	724,500	
	Scour gages............	39	Ea	500.00	19,500	
	Drop structure.........	1	Job	LS	260,000	
	Modify existing drop structures (2 ea.).....	1	Job	LS	1,700,000	
	Stabilizers (4 ea.)....	1	Job	LS	870,000	
	Levee spillway.........	1	Job	LS	200,000	
	Asphalt concrete pavement...............	4,700	Ton	45.00	211,500	
	Fencing, right-of-way..	31,000	LF	8.00	248,000	
	Santiago bridge........	1	Job	LS	101,000	
	Bitterbush bridge......	1	Job	LS	112,000	
	Side drains............	1	Job	LS	600,000	
	Esthetic treatment.....	1	Job	LS	1,011,000	
	Subtotal, channel...............................				$14,825,200	
	Contingencies...................................				2,183,800	
	Total, channel..					$17,009,000

Table XV-10. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
30	Engineering & design..					$1,155,000
31	Supervision & administration..					1,010,000
51.22	O&M Manual..					10,000
	Total, construction...					$19,184,000
	Lands & relocations:					
	Lands & damages...					700,000
	Relocations:					
	Utilities.................................				$136,000	
	Bridges...................................				5,166,000	
	Recreation................................				97,000	
	Total, relocations..					$5,399,000
	Total, lands & relocations..					$6,099,000
	Total...					$25,283,000
	Preconstruction engineering & design..................................					515,000
	Total project cost, Santa Ana River Mainstem, Reach 5.................					$25,798,000

Table XV-11. Santa Ana River Mainstem, Reach 6
Detailed Estimate of First Cost
Orange Freeway to Glassell Street
(Stations 689+85 to 865+15)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	FLOOD CONTROL					
	Construction:					
02	Relocation:					
	Modify AT&SF RR Bridge.	1	Job	LS	$150,000	
	Modify SPRR Bridge.....	1	Job	LS	100,000	
	Utilities.............	1	Job	LS	273,500	
09	Channel:					
	Diversion & control of water...............	1	Job	LS	120,000	
	Clearing & grubbing....	1	Job	LS	100,000	
	Excavation channel.....	463,000	CY	$2.40	1,111,200	
	Excavation toe.........	111,000	CY	2.35	260,850	
	Compacted fill.........	253,000	CY	2.50	632,500	
	Toe fill...............	84,000	CY	3.00	252,000	
	Disposal excess mat'l..	237,000	CY	0.90	213,300	
	Stone work					
	15" stone layer.....	65,000	CY	29.00	1,885,000	
	21" stone layer.....	18,000	CY	29.00	522,000	
	24" stone layer.....	17,000	CY	29.00	493,000	
	Grout...............	29,200	CY	50.00	1,460,000	
	Remove and salvage stone..................	187,000	Ton	12.00	2,244,000	
	Portland cement........	220,000	CWT	4.50	990,000	
	Scour gages............	43	Ea	500.00	21,500	
	Modify existing drop structures (3 ea.).....	1	Job	LS	1,800,000	
	Stabilizers (7 ea.)....	1	Job	LS	1,721,000	
	Levee spillway.........	1	Job	LS	1,075,000	
	Asphalt concrete pavement...............	5,810	Ton	45.00	261,450	
	Fencing, right-of-way..	35,100	LF	8.00	280,800	
	Side drains............	1	Job	LS	665,000	
	Carbon Canyon Bridge...	1	Job	LS	150,000	
	Esthetic treatment.....	1	Job	LS	1,800,000	
	Subtotal, channel................................				$18,582,100	
	Contingencies....................................				2,817,900	
	Total, channel...					$21,400,000

Table XV-11. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
30	Engineering & design					$1,454,000
31	Supervision & administration					1,302,000
51.22	O&M Manual					10,000
	Total, construction					$24,166,000
	Lands & relocations:					
	Lands & damages					800,000
	Relocations:					
	Utilities				$69,000	
	Bridges				3,978,000	
	Recreation				40,000	
	Total, relocations					$4,087,000
	Total, lands & relocations					$4,887,000
	Total					$29,053,000
	Preconstruction engineering & design					647,000
	Total project cost, Santa Ana River Mainstem, Reach 6					$29,700,000

Table XV-12. Santa Ana River Mainstem, Reach 7
Detailed Estimate of First Cost
Glassell Street to Imperial Highway
(Stations 865+15 to 1069+10)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	FLOOD CONTROL					
	Construction:					
02	Relocation:					
	Utilities..............	1	Job	LS	$128,600	
09	Channel:					
	Excavation channel.....	645,000	CY	$2.40	1,548,000	
	Excavation toe.........	133,000	CY	2.35	312,550	
	Compacted fill.........	119,000	CY	2.50	297,500	
	Toe fill...............	101,000	CY	3.00	303,000	
	Disposal excess mat'l..	558,000	CY	1.50	837,000	
	Stone work					
	15" stone layer......	102,000	CY	26.00	2,652,000	
	Grout................	46,000	CY	50.00	2,300,000	
	Remove stone...........	261,000	Ton	12.00	3,132,000	
	Portland cement........	343,000	CWT	4.50	1,543,500	
	Scour gages............	38	Ea	500.00	19,000	
	Modify existing drop structures (4 ea.).....	1	Job	LS	1,700,000	
	Drop structure.........	1	Job	LS	1,200,000	
	Stabilizers (7 ea.)....	1	Job	LS	1,700,000	
	Levee spillway.........	1	Job	LS	1,300,000	
	Asphalt concrete pavement...............	6,600	Ton	45.00	297,000	
	Fencing, right-of-way..	41,000	LF	8.00	328,000	
	Side drains............	1	Job	LS	1,445,000	
	Esthetic treatment.....	1	Job	LS	1,297,000	
	Subtotal, channel............................				$22,340,150	
	Contingencies................................				3,368,850	
	Total, channel..					$25,709,000
30	Engineering & design......................................					1,746,000
31	Supervision & administration..............................					1,499,000
51.22	O&M Manual..					10,000
	Total, construction.......................................					$28,964,000

Table XV-12. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	Lands & relocations:					
	Lands & damages..					$1,000,000
	Relocations:					
	Bridges....................................				$1,303,000	
	Recreation.................................				75,000	
	Total, relocations...					$1,378,000
	Total, lands & relocations.....................................					$2,378,000
	Total..					$31,342,000
	Preconstruction engineering & design...........................					645,000
	Total project cost, Santa Ana River Mainstem, Reach 7..............................					$31,987,000

Table XV-13. Santa Ana River Mainstem, Reach 8
Detailed Estimate of First Cost
Imperial Highway to Weir Canyon Road
(Stations 1069+10 to 1218+20)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	FLOOD CONTROL					
	Construction:					
09	Channel:					
	Diversion & control of water.................	1	Job	LS	$140,000	
	Clearing & grubbing......	1	Job	LS	100,000	
	Excavation channel.......	350,000	CY	$2.40	840,000	
	Excavation toe...........	153,000	CY	2.35	359,550	
	Compacted fill...........	262,000	CY	2.50	655,000	
	Toe fill.................	117,000	CY	3.00	351,000	
	Disposal excess mat'l....	124,000	CY	2.75	341,000	
	Stone work					
	15" stone layer........	80,000	CY	26.00	2,080,000	
	Grout..................	36,000	CY	50.00	1,800,000	
	Removal stone...........	161,000	Ton	12.00	1,932,000	
	Portland cement..........	269,000	CWT	4.50	1,210,500	
	Scour gages..............	30	Ea	500.00	15,000	
	Modify existing drop structure...........	1	Job	LS	570,000	
	Drop structures (2 ea.)..	1	Job	LS	2,400,000	
	Stabilizers (3 ea.)......	1	Job	LS	645,000	
	Levee Spillway...........	1	Job	LS	4,300,000	
	Asphalt concrete pavement................	4,500	Ton	45.00	202,500	
	Fencing, right-of-way....	28,000	LF	8.00	224,000	
	Side drains..............	1	Job	LS	2,040,000	
	Esthetic treatment.......	1	Job	LS	242,000	
	Subtotal, channel.............................				$20,447,550	
	Contingencies.................................				3,064,450	
	Total, channel..					$23,512,000
30	Engineering & design..					1,597,000
31	Supervision & administration......................................					1,455,000
51.22	O&M Manual..					10,000
	Total, construction...					$26,574,000

Table XV-13. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	Lands & relocations:					
	Lands & damages					$700,000
	Relocations:					
	Bridges				$68,000	
	Recreation				83,000	
	Total relocations					$151,000
	Total lands & relocations					$851,000
	Total					$27,425,000
	Preconstruction engineering & design					589,000
	Total, flood control, Santa Ana River Mainstem, Reach 8					$28,014,000

Table XV-14. Santa Ana River Mainstem, Reach 9
Detailed Estimate of First Cost
Weir Canyon Road to Corona Freeway
(Stations 1218+20 to 1607+50)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Total
	FLOOD CONTROL					
	Construction:					
09	Channel:					
	Clearing & grubbing....	1	Job	LS	$25,000	
	Excavation revetment...	201,000	CY	$2.40	482,400	
	Compacted fill.........	10,000	CY	2.50	25,000	
	Miscellaneous fill.....	172,000	CY	1.50	258,000	
	Disposal excess mat'l..	19,000	CY	2.75	52,250	
	Stone work					
	12" stone layer......	8,300	CY	30.00	249,000	
	36" stone layer......	6,000	CY	30.00	180,000	
	Grout................	80	CY	50.00	4,000	
	Portland cement........	600	CWT	4.50	2,700	
	Sheet pile.............	4,600	SF	30.00	138,000	
	Subtotal, channel..............................				$1,416,350	
	Contingencies..................................				213,650	
	Total, channel..					$1,630,000
30	Engineering & design..					111,000
31	Supervision & administration......................................					96,000
51.22	O&M Manual..					10,000
	Total, construction...					$1,847,000
	Lands & relocations:					
	Total, lands..					$24,739,000
	Preconstruction Engineering & Design..............................					569,000
	Total,Santa Ana River Mainstem, Reach 9...........................					$27,155,000
	RECREATION					
	Construction:					
14	Recreation facilites:					
	Subtotal, equestrian and bike trails.............				$462,000	
	Contingencies....................................				70,000	
	Total, recreation facilities..................................					$532,000

Table XV-14. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
30	Engineering and design..					$36,000
31	Supervision and administration..................................					32,000
	Total, construction..					$600,000
	Preconstruction Engineering & Design.........................					12,000
	Total Recreation Cost..					$612,000
	Total project cost, Santa Ana River Mainstem, Reach 9............................					$27,767,000

Table XV-15. Santa Ana River Mainstem, Reach 10
Detailed Estimate of First Cost
Greenville-Banning Channel
(Stations 9+50 to 177+00)

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Total
	FLOOD CONTROL					
	Construction:					
09	Channel:					
	Diversion & control of water	1	Job	LS	$100,000	
	Clearing & grubbing	1	Job	LS	50,000	
	Borrow	30,000	CY	$2.00	60,000	
	Excavation channel	325,000	CY	2.40	780,000	
	Compacted fill	35,000	CY	2.50	87,500	
	Compacted fill, wall	320,000	CY	5.00	1,600,000	
	Removal concrete	300	CY	55.00	16,500	
	Concrete, invert	14,000	CY	70.00	980,000	
	Concrete, footing	26,000	CY	95.00	2,470,000	
	Concrete, wall	22,000	CY	110.00	2,420,000	
	Concrete, side slopes	4,200	CY	105.00	441,000	
	Portland cement	370,000	CWT	4.50	1,665,000	
	Steel reinforcement	7,100,000	Lbs	0.45	3,195,000	
	Stabilizer	1	Job	LS	38,000	
	Asphalt concrete pavement	2,200	Ton	45.00	99,000	
	Fencing, channel wall	24,000	LF	6.00	144,000	
	Fencing, right-of-way	17,000	LF	8.00	136,000	
	Side drains	1	Job	LS	103,000	
	Subdrainage System	1	Job	LS	1,125,000	
	Esthetic treatment	1	Job	LS	100,000	
	Detention ponds & siphon	1	Job	LS	427,500	
	Subtotal, channel				$16,037,500	
	Contingencies				2,562,500	
	Total, channel					$18,600,000
30	Engineering & design					352,000
31	Supervision & administration					1,112,000
51.22	O&M Manual					10,000
	Total, construction					$20,074,000

Table XV-15. (Continued)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	Lands & relocations:					
	Lands & damages					$1,610,000
	Relocations:					
	Victoria Pond					150,000
	Total, lands & relocations					$1,760,000
	Total					$21,834,000
	Preconstruction engineering & design					1,506,000
	Total project cost, Santa Ana River Mainstem, Reach 10					$23,340,000

Table XV-16. Santa Ana River Mainstem
Detailed Estimate of First Cost
Fish and Wildlife Enhancement
and Restoration

(October 1987 Price Levels)

Cost Acct No.	Description	Quantity	Unit	Unit Cost	Amount Subtotal	Amount Total
	FISH AND WILDLIFE					
01	Fish and wildlife enhancement lands					$7,258,000
	Construction:					
02	Relocations:					
	Abandon wells	1	Job	LS	$210,700	
	Relocate wells	1	Job	LS	500,000	
	Abandon power poles	16	Ea	2,000.00	32,000	
	Utilities relocations	1	Job	LS	81,000	
06	Fish and wildlife enhancement:					
	Regrading work:					
	Clearing & grubbing	1	Job	LS	105,000	
	Excavation	263,000	CY	$2.40	631,200	
	Compacted fill	89,000	CY	2.50	222,500	
	Disposal, excess mat'l.	174,000	CY	8.50	1,479,000	
	Pipe, 16" steel	160	LF	14.00	2,240	
	Pipe, 60" RCP	100	LF	75.00	7,500	
	Culvert, 6'x3' RCB	50	LF	150.00	7,500	
	Concrete headwall	15	CY	250.00	3,750	
	Cement	86	Cwt	4.50	387	
	Auto. gate (5' circ.)	2	EA	30,000.00	60,000	
	Auto. gate (6'x3')	1	EA	30,000.00	30,000	
	Gate controls	2	EA	30,000.00	60,000	
	Emergency power	2	EA	50,000.00	100,000	
	Training dike	1	Job	LS	1,091,000	
	Planting restoration	1	Job	LS	221,000	
	Subtotal				$4,844,777	
	Contingencies				725,223	
	Total					$5,570,000
30	Engineering & design					0
31	Supervision & administration					333,000
51.22	O&M Manual					30,000
	Total, construction					$5,933,000
	Total					$13,191,000
	Preconstruction engineering and design					542,000
	Total project cost Fish & Wildlife Enhancement & Restoration					$13,733,000

XVI. DESIGN AND CONSTRUCTION SCHEDULE

General

16-01 Pre-construction planning including the preparation of final plans and specifications will commence immediately upon approval of this Phase II General Design Memorandum. The work to be accomplished will include the following:

1. Final plans and specifications for construction of the 92-acre marsh.

2. Final plans and specifications for construction of each of the individual channel reaches.

Contract plans and specifications are scheduled to be completed within 6 years and construction to be completed within 8 years.

Feature Design Memorandum

16-02 Feature Design Memorandums are scheduled for Interior Drainage, and Design and Construction Materials.

Preparation of Plans and Specifications

16-03 This Phase II GDM will be the basis for the preparation of plans and specifications and constitutes designs for the major elements for the final channel construction. The design for bridges, structures and utilities as required, will be provided by the local sponsor and will be incorporated into the final plans.

Surveys and Mapping Requirements

16-04 Due to the intense urbanized nature of the project area, it is anticipated that existing conditions will change throughout the period of planning and final design. New topographic mapping will be conducted prior to initiation of each design reach.

Sequence of Construction

16-05 The sequence of construction for the recommended mainstem project are as follows:

1. Reach 1 - Fairview Channel to Pacific Ocean (station 7+60 to station 150+32).

Marsh Restoration - This work can be included or constructed by a separate contract from the mainstem channel reach. The restoration would include excavating new channels, deepening the existing channel, construction of a nesting island for the least terns, and installing two gate structures for tidal exchange.

Talbert Channel - This work will be performed by the county as a relocation project and will be constructed prior to the Corps construction at the mouth of the mainstem channel. Construction of the Pacific Coast Highway widening by CALTRANS in 1988-89 will provide a new bridge constructed in the dry along the relocated Talbert Channel alignment. Construction of the outlet channel to the ocean is planned for completion within two years.

Mainstem Channel - The construction of the Mainstem Channel will follow the relocation of Talbert Channel and the diversion of flows from Greenville-Banning Channel (G/B) to the main channel (see para. 4 below). A new bridge across the river is planned for construction in October, 1988 by CALTRANS as part of the Pacific Coast Highway widening project. During the construction of the Mainstem Channel, tidal flow to the marsh presently provided from G/B will be provided by two temporary gates until the final features for the marsh gates are completed. Construction of the Greenville-Banning Channel should be completed prior to constructing Reach 2 of the mainstem so that G/B flows can be redirected to the new G/B Channel. Construction of Reach 2 of the mainstem should follow Reach 1. Grading at the mouth will require removal of the existing stone jetties and concrete channel inverts for the Greenville-Banning Channel, the mainstem channel and the Talbert Channel. Modification of the recommended channel under the new PCH Bridge will be minimal since the new bridge design has been fully coordinated with CALTRANS. It is anticipated that excavation for the new channel invert will not extend beyond the outlet channel stabilizer at station 13+40. Excavation beyond this point is unnecessary since sediment at the mouth will be replaced by the coastal procedure almost immediately. Disposal of excess sediment

at the mouth is expected to be hydraulically dredged for near-shore disposal or placed immediately downcoast at Newport Beach to create new beach areas. Limited access for construction equipment within the channel invert may be provided by constructing a temporary haul road or diversion levee. Dump stone for the stabilizer at the mouth may be delivered and placed by barge at the site.

2. Reach 2 to 8 - Mainstem Channel construction (station 150+32 to station 1218+20).

Construction of Reaches 2-8 will pose no special construction problems. Special considerations will be given to the coordination of all utilities, bridge reconstruction and traffic control, and rights-of-way acquisition. Although the overall recommended project is separate into 10 separate reaches, construction contracts may be combined as necessary to accomodate the type of construction or availability of funds.

3. Reach 9 - Santa Ana River Canyon Weir Canyon to Prado Dam (station 1218+20 to station 1607+50). Construction in the Santa Ana River Canyon will be limited to bank stabilization between station 1489+00 and station 1515+00 for protection of the mobile homes behind the Green River Golf Course. Construction for this reach does not require any special sequence in relation to the other reaches.

4. Reach 10 - Greenville-Banning Channel - Construction of the Greenville-Banning Channel will be combined with Reach 1 of the mainstem construction. Diversion of flow from Greenville-Banning to the main channel is necessary during construction of the mainstem portion of the channel. Interim drainage flows from Greenville-Banning cannot be blocked off completely. The sequence of construction with the diversion of channel flows will be fully detailed in the final plans and specifications.

Design, construction and funding schedules for each of the Lower Santa Ana River Mainstem reaches is presented on plates XVI-1 through XVI-7.

16-06 The project construction will generate about 4,500,000 cubic yards of excess material which will be disposed of by the following options:

Reaches 1 and 2 - Lower channel mouth. Within each of the first two reaches of channel construction, about 1.5 million cubic yards of excess material will be generated at about 1 year intervals. About 500,000 cubic yards would be placed along the existing Newport Beach groins fields located immediately downcoast of the river mouth. Another 1.0 million cubic yards may be placed along the near shore or on the downcoast beach. The remaining excess generated from further upstream would be disposed at the option of the contractor.

Reaches 3 through 10 - Upper River Channel. The upper reaches do not generate an excessive amount of material to be disposed of. Haul distances are too great for beach disposal. Disposal areas for these reaches of construction will be provided by the local sponsor or at the option of the contractor. A nearby disposal site located adjacent to the river at Lincoln Avenue is the R.J. Noble pit.

Marsh restoration disposal - The closest disposal site for excess material from the regrading of the marsh is the Coyote Canyon Landfill site. This site is located in Irvine, about 10 miles east of the marsh. This is a class III site (general commercial and household waste). Hazardous material found from the restoration grading will be treated on-site prior to disposal to any nearby disposal site. In the event a class I site (hazardous material disposal) is required, the nearest site is located in the vicinity of Kettleman City, about 200 miles from the project. Material not suitable for beach disposal will either be used for miscellaneous levee fills or disposed of at the nearest landfill site located within Orange County. Table XVI-1 lists the construction reaches and the estimated amount of excess material.

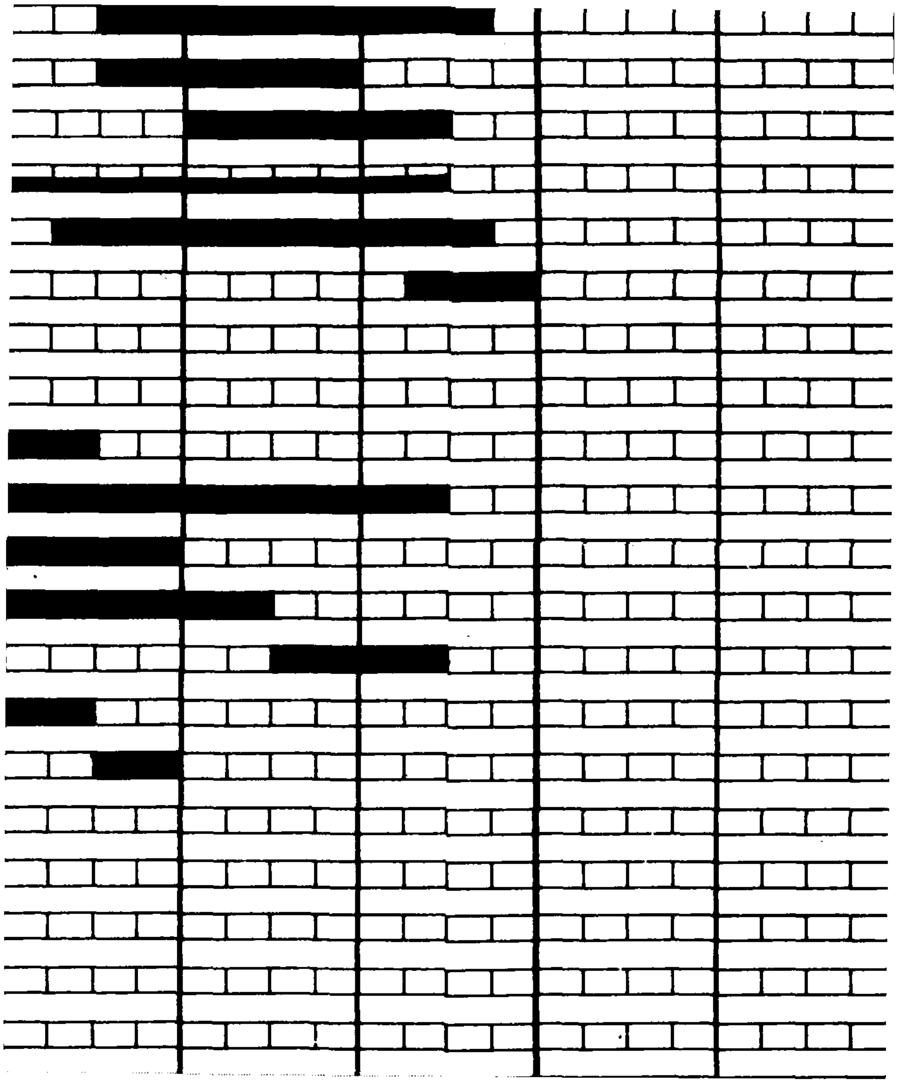
Construction Schedule and Funding

16-07 Completion of the Feature Design Memorandums, preparation of plans and specifications, and construction of the lower channel is scheduled over a period of 8 years. Initial construction will begin starting at the Pacific Ocean (Reach 1) including the restoration of the 92-acre marsh and Greenville-Banning (Reach 10). Channel construction will then continue upstream. The acquisition of land and improvements within the canyon area may be accomplished concurrently with the lower river improvements. The 30-miles of project including Greenville-Banning Channel will be divided into separate reaches for ease of construction and funding appropriations. The construction schedules shown on plates XVI-1 through XVI-7 can be modified or combined as required based on total project requirements (by reaches). The overall total project construction schedule is provided in the main report including the total Federal and non-Federal funding requirements.

Table XVI-1. Project Excavation and Fill.

	Excavation (c.y.)	Compacted Fill (c.y.)	Excess Material Excavated (c.y.)	Borrow (c.y.)	Toe Fill (c.y.)	Misc. Fill (c.y.)
Reach 1	2,035,000	473,000	1,402,000	0	160,000	0
Reach 2	1,825,000	458,000	1,367,000	0	0	0
Reach 3	395,000	47,000	339,000	0	0	9,000
Reach 4	370,000	95,000	260,000	0	0	15,000
Reach 5	491,000	552,000	0	152,000	91,000	0
Reach 6	574,000	253,000	237,000	0	84,000	0
Reach 7	778,000	119,000	558,000	0	101,000	0
Reach 8	503,000	262,000	124,000	0	117,000	0
Reach 9	201,000	10,000	19,000	0	0	172,000
Reach 10	325,000	355,000	0	30,000	0	0
TOTAL	7,497,000	2,624,00	4,306,000	182,000	553,000	196,000

Concrete Rectangular Concrete Trapezoidal
ENGINEERING & DESIGN
SUPERVISION & ADMINISTRATION
OPERATION & MAINT. MANUAL
TOTAL CONSTRUCTION COST
MITIGATION LANDS
LANDS & DAMAGES:
RELOCATIONS
Utilities (incl.oil wells)
Bridges
Recreation (trails)
Talbert Channel
Victoria Pond

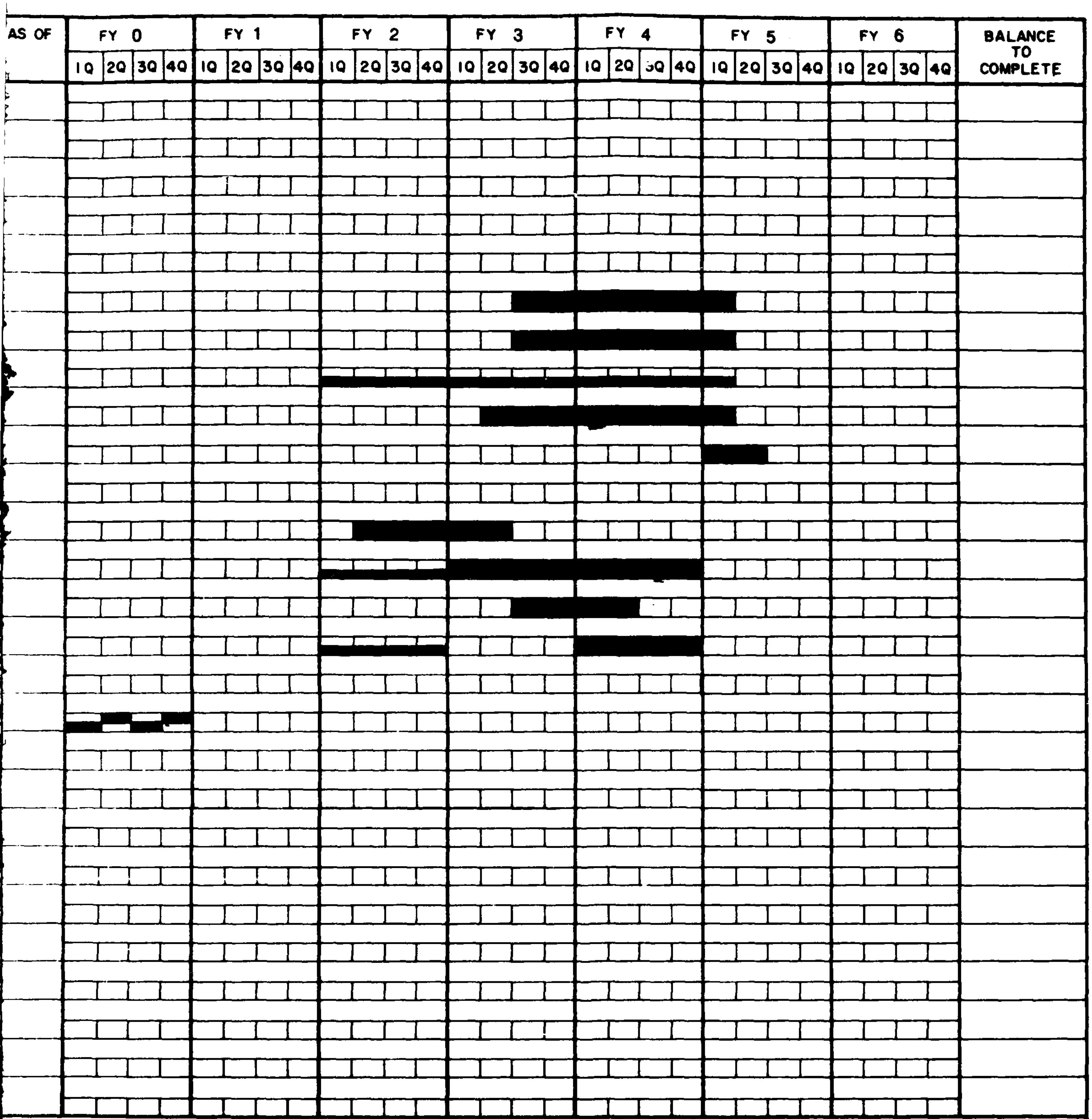


LINE NO	UNIFORM COST CLASSIFICATION	FEATURE ITEMS	PROJECT COST ESTIMATE	TOTAL AS OF	FY 0		
					1Q	2Q	3
1		LOWER SANTA ANA RIVER CHANNEL					
2		REACH 2					
3		FAIRVIEW CHAN. TO SAN DIEGO FRWY.					
4		STA. 150+32 TO 273+00					
5	02.	RELOCATIONS	326				
6	09.	CHANNEL-	58,878				
7		Concrete Rectangular	(58,878)				
8	30	ENGINEERING & DESIGN	4,023				
9	31	SUPERVISION & ADMINISTRATION	3,556				
10	51.22	OPERATION & MAINT. MANUAL	10				
11		TOTAL CONSTRUCTION COST	66,793				
12		LANDS & DAMAGES	600				
13		RELOCATIONS	630				
14		Bridges	(600)				
15		Recreation	(30)				
16		TOTAL LERRD COST	1,230				
17		PRE CONSTRUCTION E & D	1,452				
18		TOTAL PROJECT FIRST COST	69,475				
19							
20							
21							
22							
23							
24							
25							
26							
27							

FUNDS IN THOUSANDS OF DOLLARS

PRE-CONST DESIGN NO ACTIVITY CONSTRUCTION

SPL FORM 571 1 NOV 72



DESIGN AND CONSTRUCTION SCHEDULE

U.S. ARMY ENGINEER DISTRICT

LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY DESIGN MEMORANDUM NO.

DATED SHEET 2 OF 7

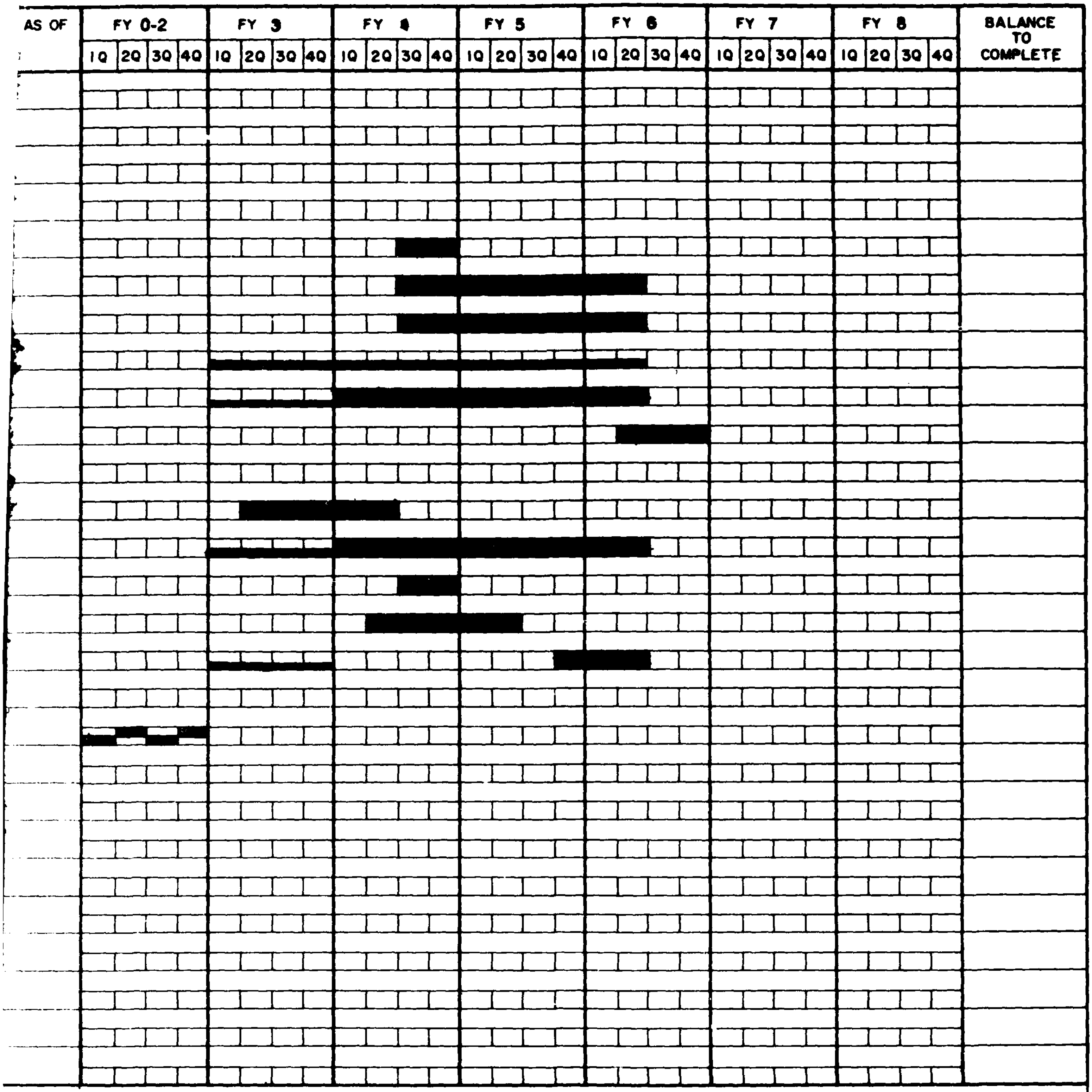
PLATE XVI -2

LINE NO	UNIFORM COST CLASSIFICATION	FEATURE ITEMS	PROJECT COST ESTIMATE	TOTAL AS OF	FY 1Q	2Q
1		LOWER SANTA ANA RIVER CHANNEL				
2		REACH 3 & 4				
3		SAN DIEGO FRWY. TO RIVER VIEW GOLF				
4		STA. 273+00 TO STA. 535+80				
5	02	RELOCATIONS	146			
6	09	CHANNEL	47,263			
7		Concrete Trapezoidal	(47,263)			
8	30	ENGINEERING & DESIGN	3,221			
9	31	SUPERVISION & ADMINISTRATION	2,882			
10	51.22	MAINTENACE MANUAL	20			
11		TOTAL CONSTRUCTION COST	53,532			
12		LANDS & DAMAGES	1,200			
13		RELOCATIONS	3,381			
14		Utilities	(224)			
15		Bridges	(2,643)			
16		Recreation	(514)			
17		TOTAL LERRD COST	4,581			
18		PRE-CONSTRUCTION E & D	1,234			
19		TOTAL PROJECT FIRST COST	59,347			
20						
21						
22						
23						
24						
25						
26						
27						

FUNDS IN THOUSANDS OF DOLLARS

PRE-CONST DESIGN NO ACTIVITY CONSTRUCTION

SPL FORM 571 1 NOV 72



DESIGN AND CONSTRUCTION SCHEDULE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATED SHEET 3 OF 7

PLATE XVI -3

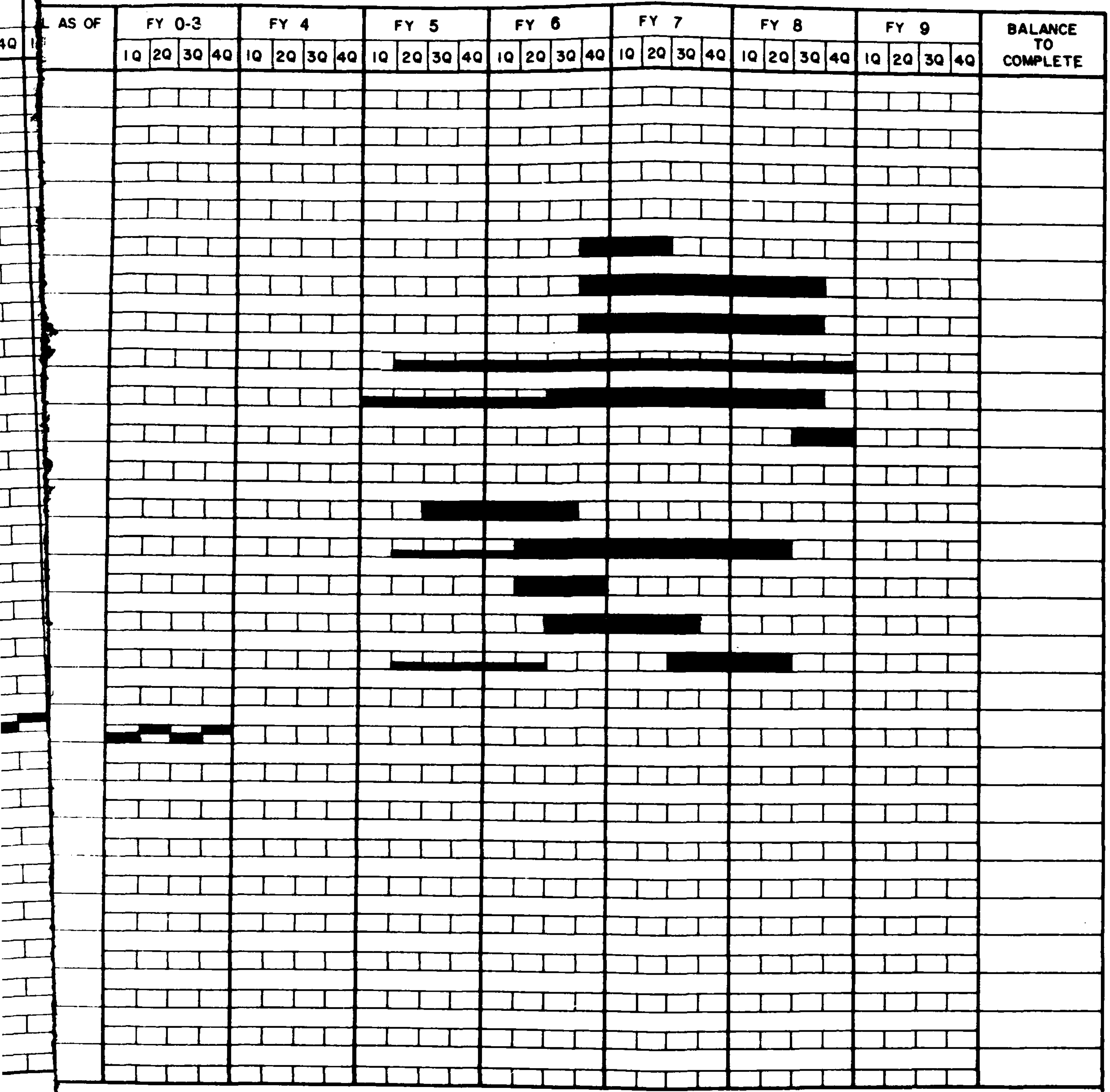
1 2

LINE NO	UNIFORM COST CLASSIFICATION	FEATURE ITEMS	PROJECT COST ESTIMATE	TOTAL AS OF	FY 1Q	2
1		LOWER SANTA ANA RIVER CHANNEL				
2		REACH 5 & 6				
3		RIVER VIEW GOLF COURSE TO GLASSEL ST				
4		STA. 535+80 TO STA. 865+15				
5	02	RELOCATIONS	1,310			
6	09	CHANNEL	37,099			
7		Riprap Trapezoidal	(37,099)			
8	30	ENGINEERING & DESIGN	2,609			
9	31	SUPERVISION & ADMINISTRATION	2,312			
10	51.22	OPERATION & MAINT. MANUAL	20			
11		TOTAL CONSTRUCTION COST	43,350			
12		LANDS & DAMAGES	1,500			
13		RELOCATIONS	9,486			
14		Utilities	(205)			
15		Bridges	(9,144)			
16		Recreation	(137)			
17		TOTAL LERRD COST	10,986			
18		PRE CONSTRUCTION E & D	1,162			
19		TOTAL PROJECT FIRST COST	55,498			
20						
21						
22						
23						
24						
25						
26						
27						

FUNDS IN THOUSANDS OF DOLLARS

PRE-CONST. DESIGN NO ACTIVITY CONSTRUCTION

SPL FORM 571 1 NOV 72



DESIGN AND CONSTRUCTION SCHEDULE

U.S. ARMY ENGINEER DISTRICT

LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY DESIGN MEMORANDUM NO.

DATED SHEET 4 OF 7

PLATE XVI -4

2

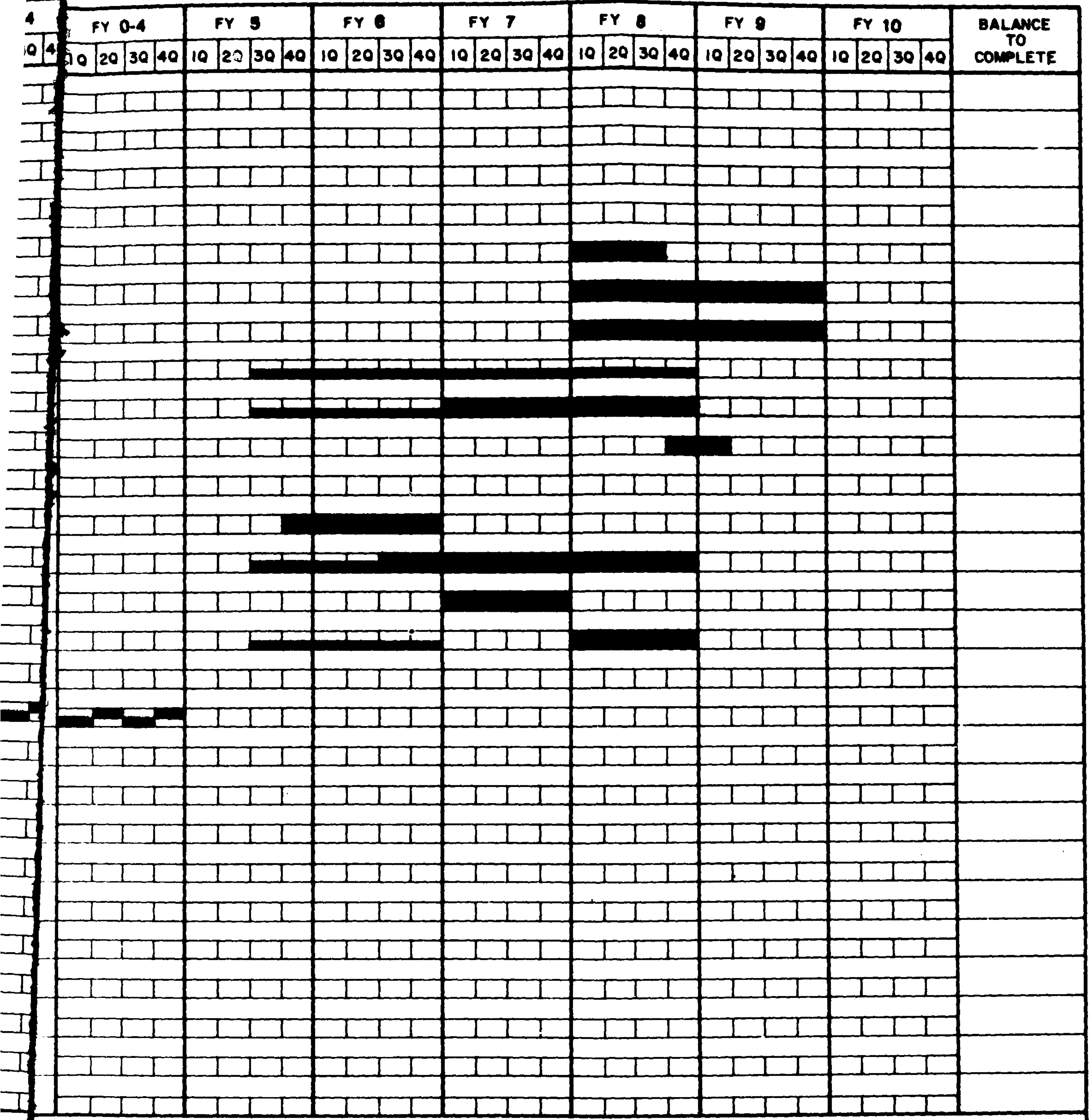
LINE NO	UNIFORM COST CLASSIFICATION	FEATURE ITEMS	PROJECT COST ESTIMATE	TOTAL AS OF	1Q
1		LOWER SANTA ANA RIVER CHANNEL			
2		REACH 7 & 8			
3		GLASSEL ST. TO WEIR CANYON			
4		STA. 865+15 TO STA. 1218+20			
5	02	RELOCATIONS	148		
6	09	CHANNEL-	49,071		
7		Riprap Trapezoidal	(49,071)		
8	30	ENGINEERING & DESIGN	3,343		
9	31	SUPERVISION & ADMINISTRATION	2,956		
10	51.22	OPERATION & MAINT. MANUAL	20		
11		TOTAL CONSTRUCTION COST	55,538		
12		LANDS & DAMAGES	1,700		
13		RELOCATIONS	1,529		
14		Bridges	(1,371)		
15		Recreation	(158)		
16		TOTAL LERRD COST	3,229		
17		PRE-CONSTRUCTION E & D	1,234		
18		TOTAL PROJECT FIRST COST	60,001		
19					
20					
21					
22					
23					
24					
25					
26					
27					

FUNDS IN THOUSANDS OF DOLLARS

PRE-CONST DESIGN NO ACTIVITY CONSTRUCTION

SPL FORM 571 1 NOV 72

1



DESIGN AND CONSTRUCTION SCHEDULE

U.S. ARMY ENGINEER DISTRICT

LOS ANGELES, CORPS OF ENGINEERS

TO ACCOMPANY DESIGN MEMORANDUM NO.

DATED SHEET 5 OF 7

PLATE XVI -5

1

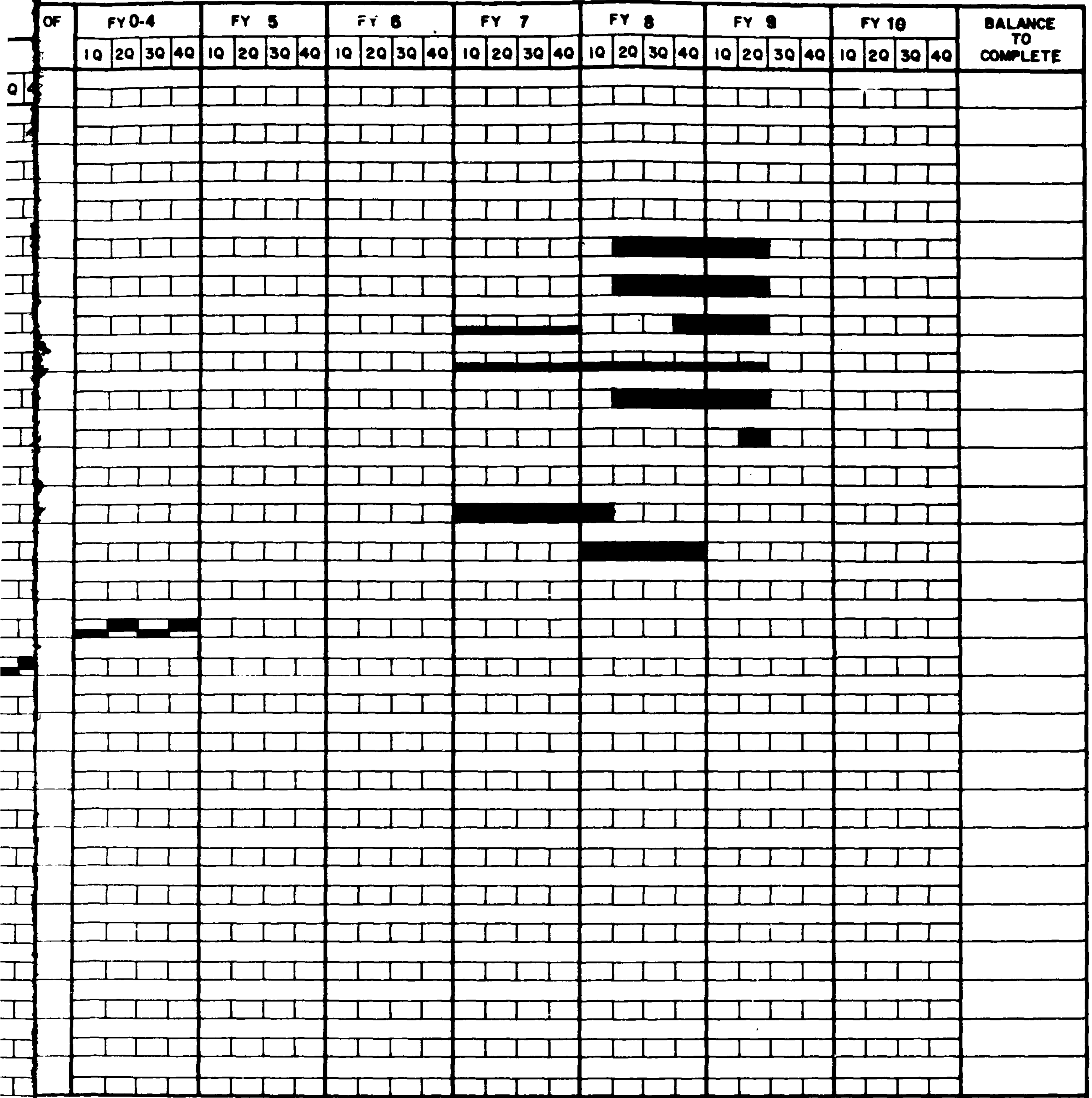
2

LINE NO	UNIFORM COST CLASSIFICATION	FEATURE ITEMS	PROJECT COST ESTIMATE	TOTAL AS OF	F
					1Q
1		LOWER SANTA ANA RIVER CHANNEL			
2		REACH 9			
3		WEIR CANYON TO CORONA			
4		STA. 1218+20 TO STA. 1607+50			
5	09	CHANNELL-	1,630		
6		Revetment (Slope Protection)	(1,630)		
7	14	RECREATION	600		
8	30	ENGINEERING & DESIGN	111		
9	31	SUPERVISION & ADMINISTRATION	96		
10	51.22	OPERATION & MAINT.MANUAL	10		
11		TOTAL CONSTRUCTION COST:	2,447		
12		LANDS & DAMAGES	24,739		
13		RELOCATIONS	0		
14		TOTAL LERRD COST	24,739		
15		PRE-CONSTRUCTION E & D	581		
16		TOTAL PROJECT FIRST COST	27,767		
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					

FUNDS IN THOUSANDS OF DOLLARS

PRE-CONST DESIGN NO ACTIVITY CONSTRUCTION

SPL FORM 1 NOV 72 571



DESIGN AND CONSTRUCTION SCHEDULE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATED SHEET 6 OF 7

PLATE XVI -6

1

2

LINE NO	UNIFORM COST CLASSIFICATION	FEATURE ITEMS	PROJECT COST ESTIMATE	TOTAL AS OF	FY 0	
					1Q	2Q
1		LOWER SANTA ANA RIVER CHANNEL				
2		FISH & WILDLIFE ENHANCEMENT				
3		(MARSH RESTORATION)				
4		CONSTRUCTION:				
5	01	ENHANCEMENT LANDS	7,258			
6	02	RELOCATIONS	947			
7	06	FISH & WILDLIFE ENHANCEMENT	4,623			
8	30	ENGINEERING & DESIGN	-			
9	31	SUPERVISION & ADMINISTRATION	333			
10	51.22	OPERATION & MAINT. MANUAL	30			
11		TOTAL CONSTRUCTION COST	5,933			
12		PRE-CONSTRUCTION E & D	542			
13		TOTAL PROJECT FIRST COST	13,733			
14						
15						
16						
17						
18						
19						
20						
21						
22						
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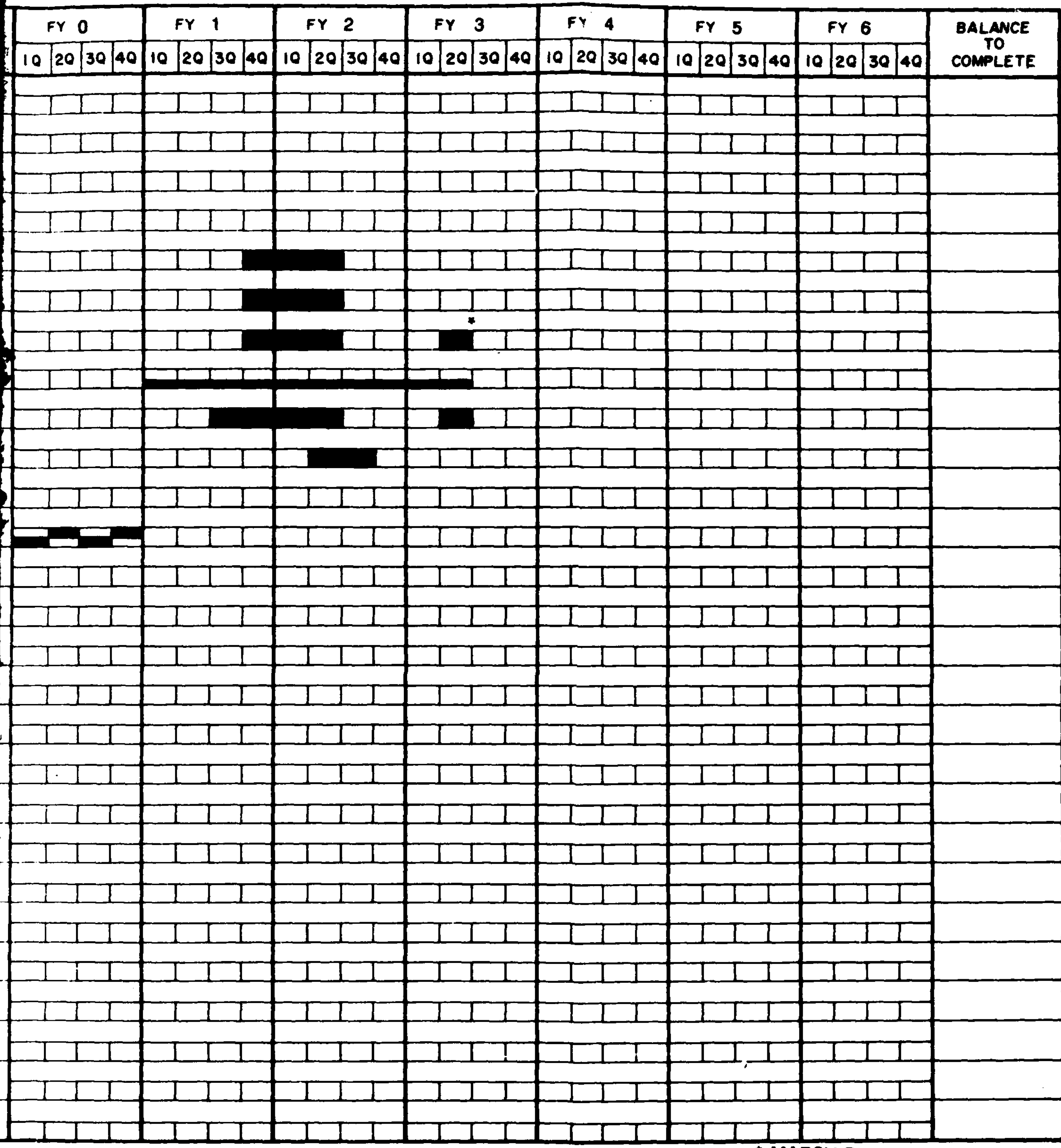
24						
25						
26						
27						

FUNDS IN THOUSANDS OF DOLLARS

PRE-CONST DESIGN NO ACTIVITY CONSTRUCTION

SPL FORM 571
1 NOV 72



* MARSH PLANTING

DESIGN AND CONSTRUCTION SCHEDULE

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMORANDUM NO.
DATED SHEET 7 OF 7

PLATE XVI -7

1 2

XVII. OPERATION AND MAINTENANCE

General

17-01 Upon completion of the proposed flood control channel project, the annual operation and maintenance cost for channel flood control features is presently estimated at $595,000, which is based on the cost for similar type of channel experienced by the Los Angeles District. In addition, the annual operation and maintenance cost for recreation features is estimated at $50,000.

17-02 An operation and maintenance (O&M) manual would be prepared after construction of the flood control improvements and marsh restoration in accordance with ER 1130-2-304 "Project Operations" and applicable provisions of ER 1150-2-301 "Local Cooperation". The estimated cost of the O&M manuals is $100,000 for the channel reaches and $30,000 for the marsh. The local sponsor would be responsible for the operation and maintenance of the flood control improvements. A breakdown of the estimated O&M manual costs by each construction reach and the marsh is shown in table XVII-1.

17-03 In general, the annual channel O&M cost will include the following:

1. Operations - administration, inspection, and evaluation.

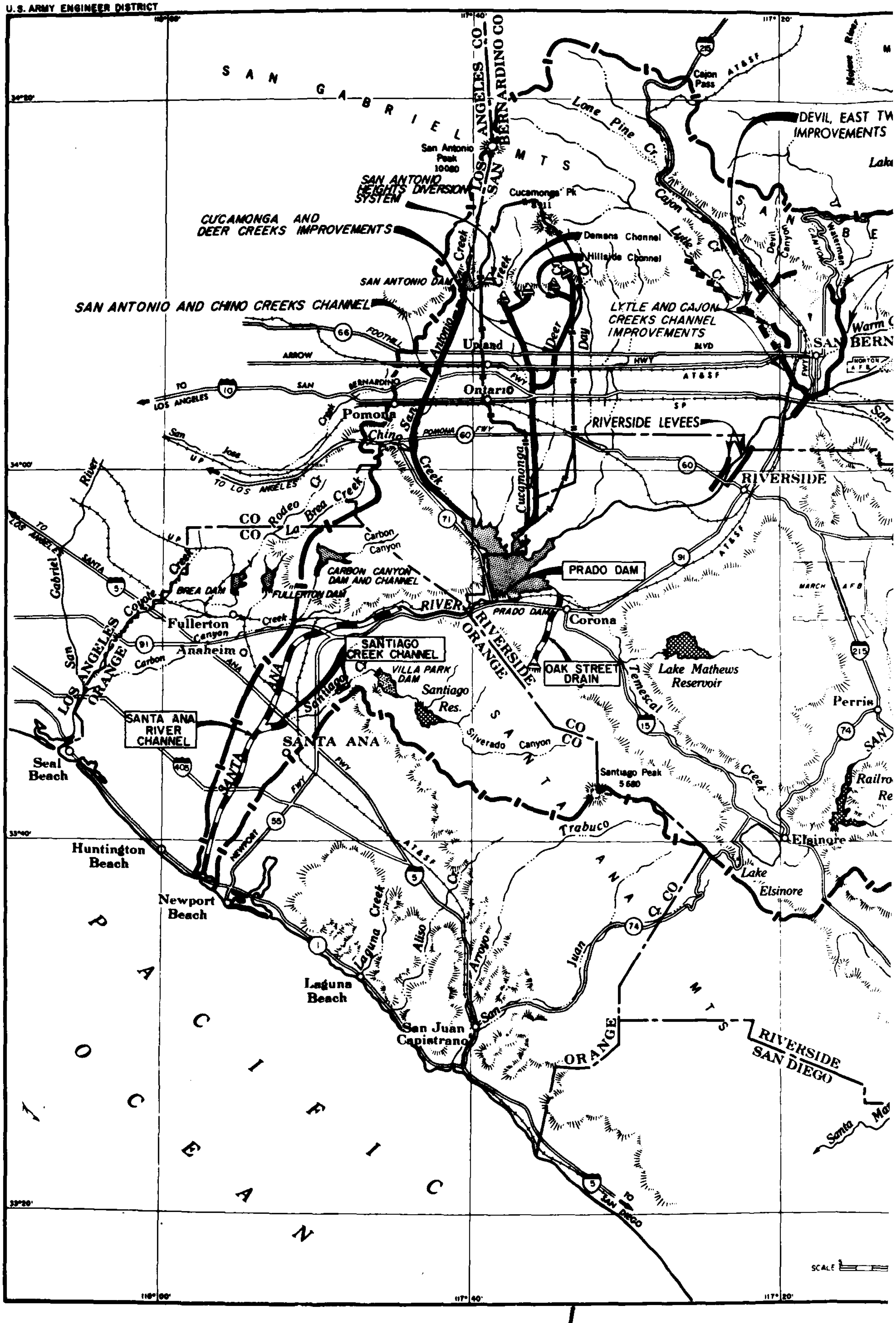
2. Maintenance - routine repairs of fence and riprap protection, weed abatement, sediment and/or debris cleanup, clean out of subdrain systems, and miscellaneous repairs.

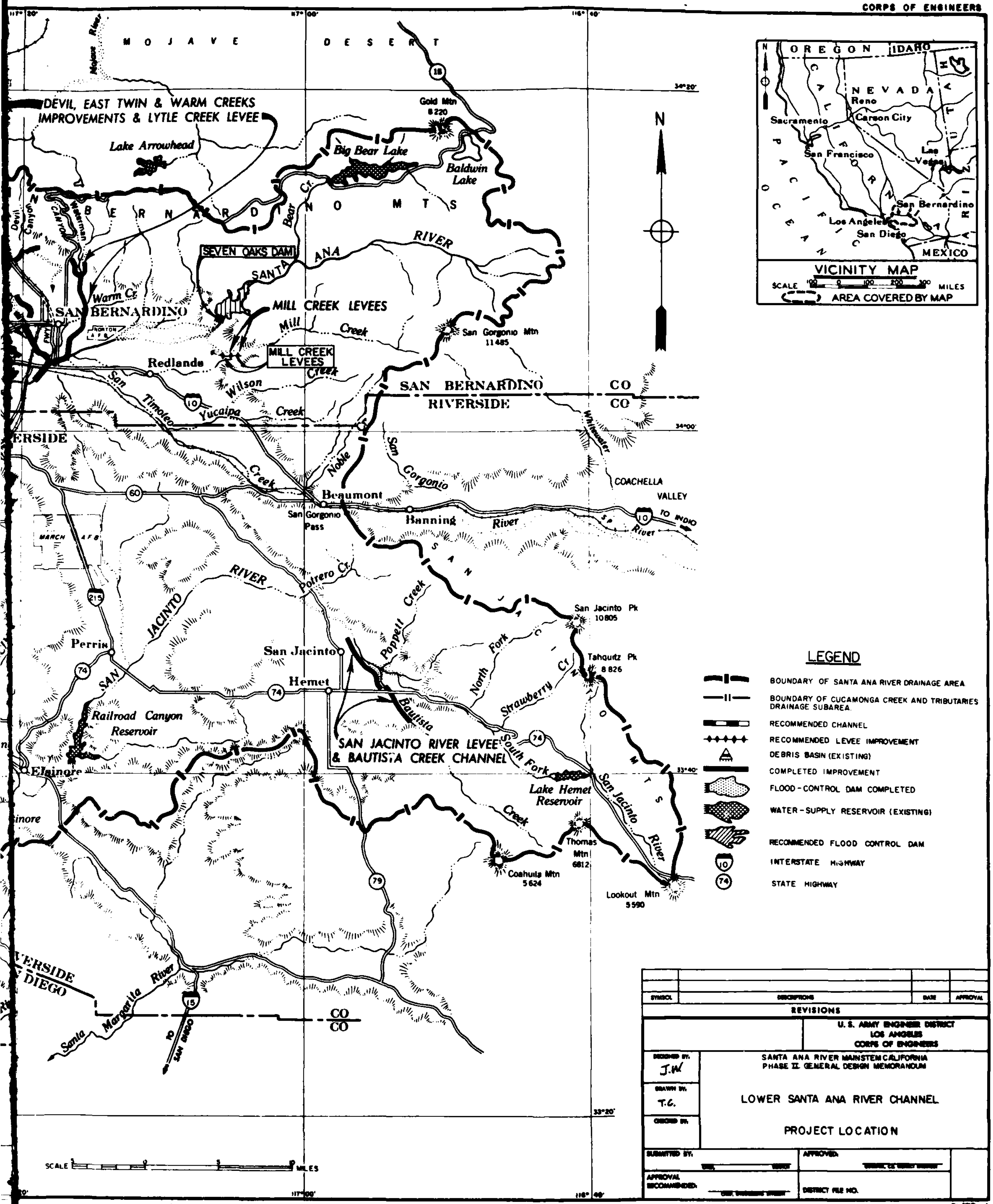
3. Major replacements - replace access road paving, flap gates, repair of concrete channel inverts, and drop structures.

Table XVII-1. Santa Ana River Mainstem Operations and Maintenance Costs.

No.	Reach	Annual Cost	O&M Manual
1.	Pacific Ocean to Fairview Channel (stations 7+60 to 150+32)	$110,000	$10,000
2.	Fairview Channel to San Diego Freeway (stations 150+32 to 273+00)	30,000	10,000
3.	San Diego Freeway to Edinger Avenue (stations 273+00 to 393+50)	35,000	10,000
4.	Edinger Avenue to River View Golf Course (Inlet) (stations 393+50 to 535+80)	40,000	10,000
5.	River View Golf Course (Inlet) to Orange Freeway (stations 535+80 to 689+85)	50,000	10,000
6.	Orange Freeway to Glassell Street (stations 689+85 to 865+15)	50,000	10,000
7.	Glassell Street to Imperial Highway (stations 865+15 to 1069+10)	50,000	10,000
8.	Imperial Highway to Weir Canyon Road (stations 1069+10 to 1218+20)	50,000	10,000
9.	Weir Canyon Road to Prado Dam (stations 1218+20 to 1607+50)	5,000	10,000
10.	Greenville-Banning Channel	50,000	10,000
	Marsh Restoration	65,000	30,000
	Recreation Trails	50,000	
	TOTAL	$645,000	$130,000

U.S. ARMY ENGINEER DISTRICT




CORPS OF ENGINEERS
MOJAVE DESERT
DEVIL, EAST TWIN & WARM CREEKS IMPROVEMENTS & LYTLE CREEK LEVEE
Lake Arrowhead
Big Bear Lake
Baldwin Lake
Gold Mtn 8 220
SEVEN OAKS DAM
SANTA ANA RIVER
MILL CREEK LEVEES
SAN BERNARDINO
Redlands
San Gorgonio Mtn 11 485
SAN BERNARDINO CO
RIVERSIDE CO
Yucaipa Creek
San Timoteo Creek
Beaumont
San Gorgonio Pass
Banning
COACHELLA VALLEY
TO INDIO
SAN JACINTO RIVER
Potrero Cr.
Poppett Creek
San Jacinto Pk 10 805
Tahquitz Pk 8 826
Perris
San Jacinto
Hemet
Railroad Canyon Reservoir
SAN JACINTO RIVER LEVEE & BAUTISTA CREEK CHANNEL
Elsinore
Lake Hemet Reservoir
Thomas Mtn 6812
Coahuila Mtn 5 624
Lookout Mtn 5 590
Santa Margarita River
TO SAN DIEGO
RIVERSIDE
SAN DIEGO
CO
CO
SCALE MILES
VICINITY MAP
OREGON
IDAHO
NEVADA
Reno
Sacramento
Carson City
San Francisco
Las Vegas
San Bernardino
Los Angeles
San Diego
MEXICO
PACIFIC OCEAN
CALIFORNIA
SCALE MILES
AREA COVERED BY MAP
LEGEND
BOUNDARY OF SANTA ANA RIVER DRAINAGE AREA
BOUNDARY OF CUCAMONGA CREEK AND TRIBUTARIES DRAINAGE SUBAREA
RECOMMENDED CHANNEL
RECOMMENDED LEVEE IMPROVEMENT
DEBRIS BASIN (EXISTING)
COMPLETED IMPROVEMENT
FLOOD-CONTROL DAM COMPLETED
WATER-SUPPLY RESERVOIR (EXISTING)
RECOMMENDED FLOOD CONTROL DAM
INTERSTATE HIGHWAY
STATE HIGHWAY
REVISIONS
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER CHANNEL
PROJECT LOCATION
J.W
T.C.
PLATE 1

VALUE EN

℄ CURVE DATA
SANTA ANA R
CONTROL LIN

P.I. 2
Δ = 13° 49' 37"
R = 2730'
T = 331.02'
L = 658.82'
B.C. STA 18+6C
E.C. STA 25+18

P.I. 5
Δ = 14° 46' 33"
R = 20,000'
T = 2593.26'
L = 5157.74'
B.C. STA 187+9
E.C. STA 239+

P.I. 9
Δ = 09° 52' 28"
R = 20,000'
T = 1727.69'
L = 3446.83'
B.C. STA 345+
E.C. STA 380+
X = 75.62'

P.I. 10
Δ = 10° 39' 48"
R = 20,000'
T = 1866.49'
L = 3722.21'
B.C. STA 387+
E.C. STA 424+

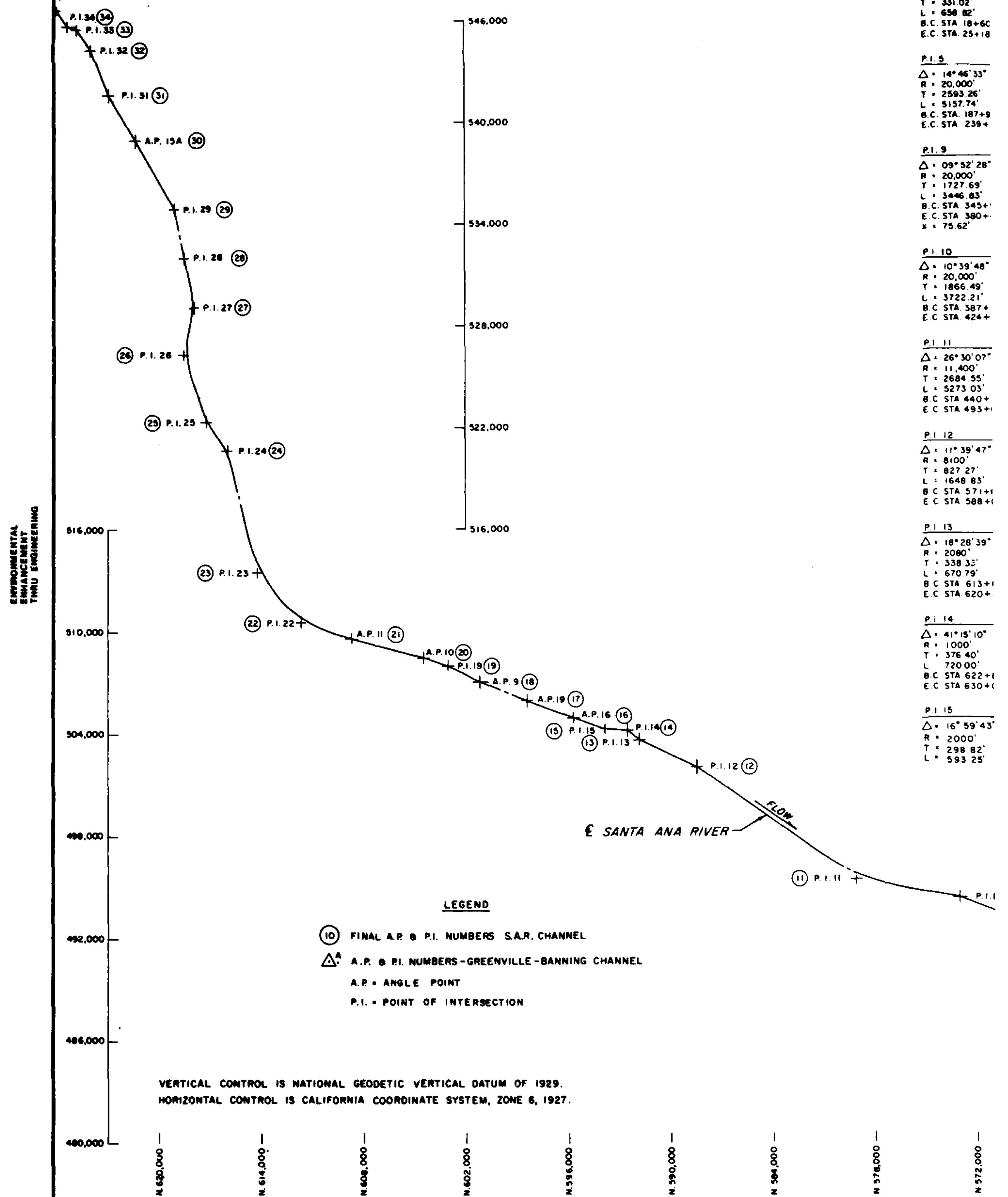
P.I. 11
Δ = 26° 30' 07"
R = 11,400'
T = 2684.55'
L = 5273.03'
B.C. STA 440+
E.C. STA 493+

P.I. 12
Δ = 11° 39' 47"
R = 8100'
T = 827.27'
L = 1648.83'
B.C. STA 571+
E.C. STA 588+

P.I. 13
Δ = 18° 28' 39"
R = 2080'
T = 338.33'
L = 670.79'
B.C. STA 613+
E.C. STA 620+

P.I. 14
Δ = 41° 15' 10"
R = 1000'
T = 376.40'
L 720.00'
B.C. STA 622+
E.C. STA 630+

P.I. 15
Δ = 16° 59' 43'
R = 2000'
T = 298.82'
L = 593.25'



PLAN
SCALE: 1 IN = 3000 FT

SAF

JE ENGINEERING PAYS

℄ CURVE DATA
SANTA ANA RIVER
CONTROL LINE

P.I. 2
Δ = 13° 49' 37"
R = 2730'
T = 331.02
L = 658.82'
B.C. STA. 18+60.11
E.C. STA. 25+18.93

P.I. 5
Δ = 14° 46' 33"
R = 20,000'
T = 2593.26'
L = 5157.74'
B.C. STA. 187+93.74
E.C. STA. 239+51.48

P.I. 9
Δ = 09° 52' 28"
R = 20,000'
T = 1727.69'
L = 3446.83'
B.C. STA. 345+97.27
E.C. STA. 380+44.10
X = 75.62'

P.I. 10
Δ = 10° 39' 48"
R = 20,000'
T = 1866.49'
L = 3722.21'
B.C. STA. 387+14.08
E.C. STA. 424+36.29

P.I. 11
Δ = 26° 30' 07"
R = 11,400'
T = 2684.55'
L = 5273.03'
B.C. STA. 440+30.35
E.C. STA. 493+03.38

P.I. 12
Δ = 11° 39' 47"
R = 8100'
T = 827.27'
L = 1648.83'
B.C. STA. 571+60.99
E.C. STA. 588+09.82

P.I. 13
Δ = 18° 28' 39"
R = 2080'
T = 338.33'
L = 670.79'
B.C. STA. 613+64.26
E.C. STA. 620+35.05

P.I. 14
Δ = 41° 15' 10"
R = 1000'
T = 376.40'
L = 720.00'
B.C. STA. 622+86.30
E.C. STA. 630+06.30

P.I. 15
Δ = 16° 59' 43"
R = 2000'
T = 298.82'
L = 593.25'

P.I. 16
Δ = 02° 32' 05"
R = 20,000'
T = 442.46'
L = 884.79'
B.C. STA. 654+44.41
E.C. STA. 663+29.20

P.I. 19
Δ = 08° 00' 27"
R = 7360'
T = 515.15'
L = 1028.61'
B.C. STA. 734+05.50
E.C. STA. 744+34.11

P.I. 22
Δ = 32° 30' 19"
R = 5500'
T = 1603.38'
L = 3120.28'
B.C. STA. 812+43.08
E.C. STA. 843+63.36

P.I. 23
Δ = 27° 54' 53"
R = 8000'
T = 1988.30'
L = 3897.63'
B.C. STA. 847+11.68
E.C. STA. 886+09.31
X = 243.38'

P.I. 24
Δ = 24° 08' 22"
R = 5500'
T = 1176.06'
L = 2317.22'
B.C. STA. 928+24.73
E.C. STA. 951+41.95
X = 124.33'

P.I. 25
Δ = 18° 39' 40"
R = 5220'
T = 857.67'
L = 1700.14'
B.C. STA. 951+97.52
E.C. STA. 968+97.67

P.I. 26
Δ = 31° 57' 42"
R = 4980'
T = 1426.19'
L = 2778.03'
B.C. STA. 988+39.63
E.C. STA. 1016+17.66

P.I. 27
Δ = 24° 23' 15"
R = 6700'
T = 1447.83'
L = 2851.80'
B.C. STA. 1016+27.70
E.C. STA. 1044+79.50

P.I. 29
Δ = 17° 28' 17"
R = 4,000'
T = 614.84'
L = 1220.13'
B.C. STA. 1084+03.70
E.C. STA. 1096+23.83

P.I. 31
Δ = 07° 19' 29"
R = 10,000'
T = 639.93'
L = 1278.11'
B.C. STA. 1160+95.95
E.C. STA. 1173+74.06

P.I. 32
Δ = 12° 23' 49"
R = 5500'
T = 597.35'
L = 1190.03'
B.C. STA. 1190+12.03
E.C. STA. 1202+02.06

P.I. 33
Δ = 37° 20' 00"
R = 500'
T = 168.92'
L = 325.80'
B.C. 1208+96.85
E.C. 1212+22.65

P.I. 34
Δ = 38° 23' 22"
R = 900'
T = 313.32'
L = 603.02'
B.C. STA. 1212+87.15
E.C. STA. 1218+90.17

℄ CURVE DATA
GREENVILLE-BANNING
CHANNEL

P.I. I
Δ = 09° 19' 24"
R = 20,000'
T = 1630.84'
B.C. STA. 118+31.61
E.C. STA. 150+86.07

P.I. J
Δ = 03° 45' 17"
R = 18,000'
T = 590.00'
B.C. STA. 154+78.15
E.C. STA. 166+57.73

P.I. K
Δ = 09° 11' 22"
R = 3600'
T = 289.16'
B.C. STA. 17 +
E.C. STA. 1 +

P.I. L
Δ = 60° 30' 46"
R = 900'
T = 525.00
B.C. STA. 177+16.90
E.C. STA. 186+16.43

(1) BEGIN SANTA ANA RIVER CONTROL LINE
STA. 6+50.13
N. 536,152.59
E. 480,096.74
N. 28° 10' 43" E.
1541.00'

(2) P.I. 2
N. 537,510.95
E. 480,824.43
N. 14° 21' 05" E.
11,416.00'

(3) A.P. 1A
STA. 136+03.91
N. 548,570.70
E. 483,654.09
N. 13° 15' 35" E.
3143.09'

(4) A.P. 2A
STA. 167+47.00
N. 551,630.00
E. 484,375.00
N. 14° 30' 00" E.
4640.00'

(5) P.I. 5
N. 556,122.21
E. 485,536.76
N. 29° 16' 33" E.
5176.57'

(6) A.P. 1
STA. 265+34.80
N. 560,637.61
E. 488,068.17
N. 30° 15' 32" E.
2605.35'

(7) A.P. 2
STA. 291+40.15
N. 562,888.00
E. 489,381.02
N. 29° 35' 15" E.
1899.72'

(8) A.P. 3
STA. 310+39.87
N. 564,540.00
E. 490,319.01
N. 29° 54' 50" E.
5285.10'

(9) P.I. 9
N. 569,121.00
E. 492,954.67
N. 20° 02' 22" E.
4264.16'

(10) P.I. 10
N. 573,127.00
E. 494,415.86
N. 09° 22' 34" E.
6145.10'

(11) P.I. 11
N. 579,190.00
E. 495,417.00
N. 35° 52' 41" E.
11,369.43'

(12) P.I. 12
N. 588,402.27
E. 502,080.18
N. 24° 12' 54" E.
3720.05'

(13) P.I. 13
N. 591,795.00
E. 503,606.00
N. 42° 41' 33" E.
965.98'

(14) P.I. 14
N. 592,505.00
E. 504,261.00
N. 01° 26' 23" E.
1313.41'

(15) P.I. 15
N. 593,818.00
E. 504,294.00
N. 18° 26' 06" E.
1947.96'

(16) P.I. 16
N. 595,666.00
E. 504,910.00
N. 20° 58' 11" E.
2917.21'

(17) A.P. 8
STA. 688+03.94
N. 598,390.00
E. 505,954.00
N. 21° 31' 53" E.
3073.48'

(18) A.P. 9
STA. 718+77.42
N. 601,429.00
E. 507,082.00
N. 25° 30' 42" E.
2043.22'

(19) P.I. 19
N. 603,093.00
E. 507,962.00
N. 17° 30' 15" E.
1479.51'

(20) A.P. 10
STA. 753+98.47
N. 604,504.00
E. 508,407.00
N. 16° 33' 50" E.
4377.66'

(21) A.P. 11
STA. 797+76.13
N. 608,700.00
E. 509,655.00
N. 16° 17' 05" E.
3070.32'

(22) P.I. 22
N. 611,647.14
E. 510,515.95
N. 48° 47' 24" E.
3940.00'

(23) P.I. 23
N. 614,242.89
E. 513,480.01
N. 76° 42' 17" E.
7379.78'

(24) P.I. 24
N. 615,940.00
E. 520,662.00
N. 52° 33' 55" E.
2089.30'

(25) P.I. 25
N. 617,210.00
E. 522,321.00
N. 71° 13' 35" E.
4225.83'

(26) P.I. 26
N. 618,570.00
E. 526,322.00
S. 76° 48' 43" E.
2884.06

(27) P.I. 27
N. 617,912.00
E. 529,130.00
N. 78° 48' 02" E.
2972.26'

(28) A.P. 14A
STA. 1060+03.94
N. 618,489.29
E. 532,045.66
N. 78° 14' 07" E.
3014.60'

(29) P.I. 29
N. 619,103.94
E. 534,996.93
N. 60° 45' 30" E.
4587.69

(30) A.P. 13A
STA. 1135+88.07
N. 621,346.00
E. 539,000.00
N. 60° 18' 26" E.
3139.20'

(31) P.I. 31
N. 622,900.00
E. 541,727.00
N. 67° 37' 49" E.
2875.25'

(32) P.I. 32
N. 623,994.27
E. 544,385.88
N. 55° 13' 59" E.
1479.14'

(33) P.I. 33
N. 624,837.73
E. 545,600.96
N. 17° 53' 59" E.
546.73'

(34) P.I. 34
N. 625,358.00
E. 545,769.00

GREENVILLE-BANNING CHANNEL
BEGIN CONTROL LINE

(A) STA. 9+50.00
N. 542,726.79
E. 482,422.13
N. 14° 21' 06" E.
400.00'

(B) A.P. B
STA. 13+50.00
N. 543,114.31
E. 482,521.28
N. 18° 09' 55" E.
601.33'

(C) A.P. C
STA. 19+51.33
N. 543,685.67
E. 482,708.75
N. 14° 21' 05" E.
4966.91'

(D) A.P. D
STA. 69+18.24
N. 548,497.58
E. 483,939.88
N. 13° 15' 43" E.
1438.11'

(E) A.P. E
STA. 83+56.35
N. 549,897.34
E. 484,269.79
N. 12° 09' 30" E.
650.72'

(F) A.P. F
STA. 90+07.07
N. 550,533.46
E. 484,406.84
N. 09° 26' 46" E.
601.33'

(G) A.P. G
STA. 96+08.64
N. 551,126.64
E. 484,505.53
N. 13° 15' 35" E.
460.00'

(H) A.P. H
STA. 100+68.40
N. 551,574.38
E. 484,611.04
N. 14° 31' 04" E.
3239.04'

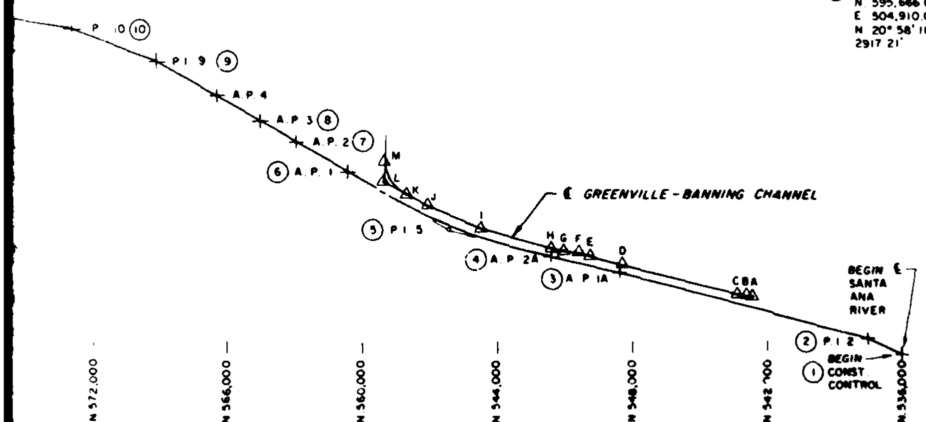
(I) P.I. I
N. 554,860.05
E. 485,461.86
N. 23° 50' 48" E.
2612.91'

(J) P.I. J
N. 557,250.00
E. 486,518.00
N. 27° 35' 45" E.
1245.12'

(K) P.I. K
N. 558,353.80
E. 487,094.95
N. 36° 47' 07" E.
929.98'

(L) P.I. L
N. 559,098.62
E. 487,651.85
S. 82° 42' 07" E.
855.08'

(M) A.P.M
END LINE
N. 558,990.00
E. 488,500.00



SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: J.T.B.
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
GREENVILLE BANNING CHANNEL
CHANNEL CONTROL DATA

DISTRICT FILE NO.

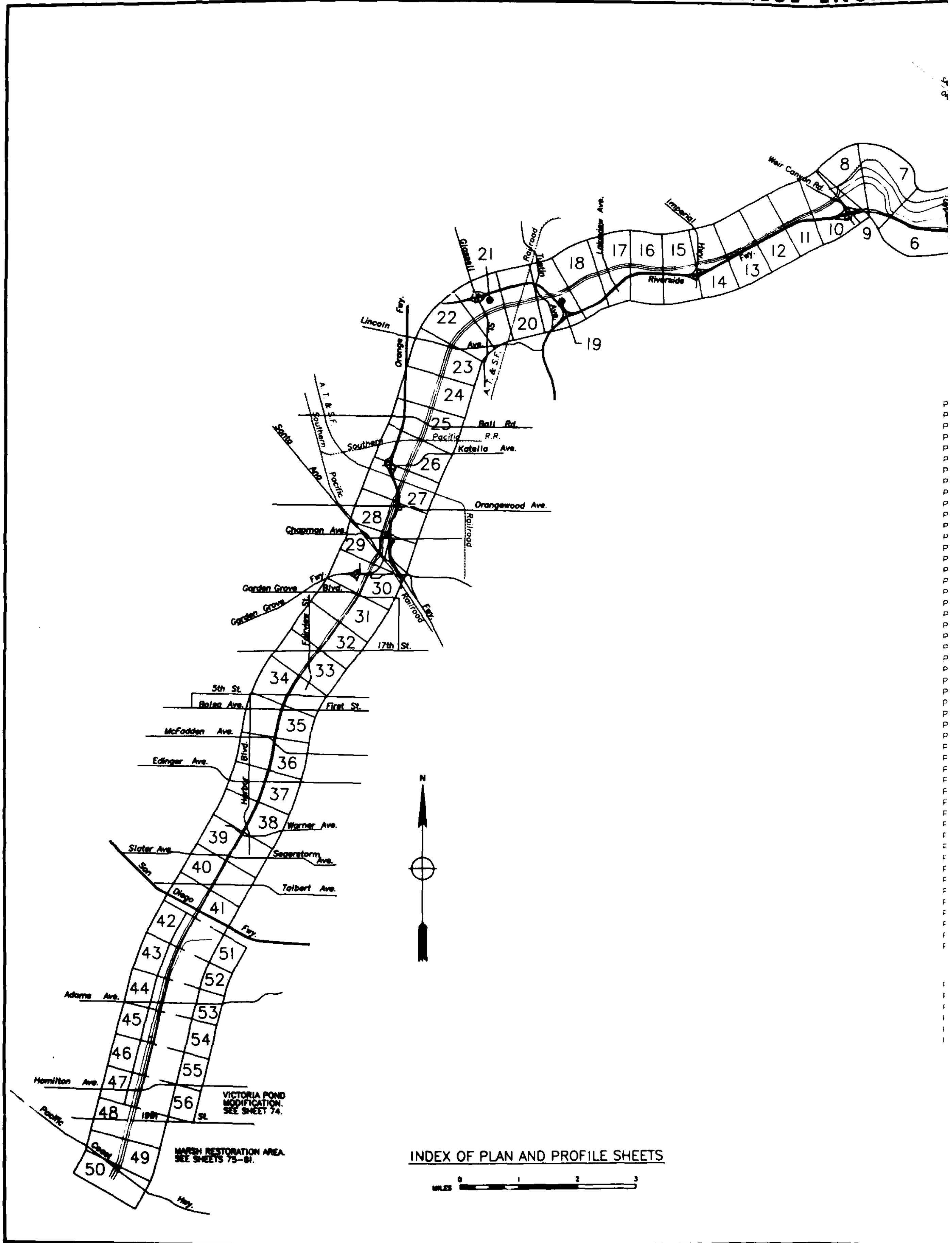
PLATE 2

SAFETY PAYS

2

VALUE ENGINEERI

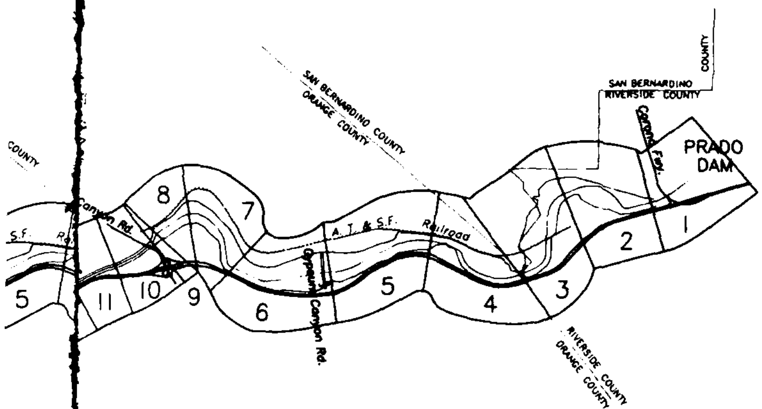
ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING



INDEX OF PLAN AND PROFILE SHEETS

SAFETY P

PAGE ENGINEERING PAYS



DESCRIPTION	SHEET NO.
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PLAN AND PROFILE – STA 1481+20 TO STA 1545+00	3
PLAN AND PROFILE – STA 1417+80 TO STA 1481+20	4
PLAN AND PROFILE – STA 1351+40 TO STA 1417+80	5
PLAN AND PROFILE – STA 1288+80 TO STA 1351+40	6
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SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
GENERAL PLAN AND INDEX

SUBMITTED BY: DATE APPROVED: SHEET
DISTRICT FILE NO

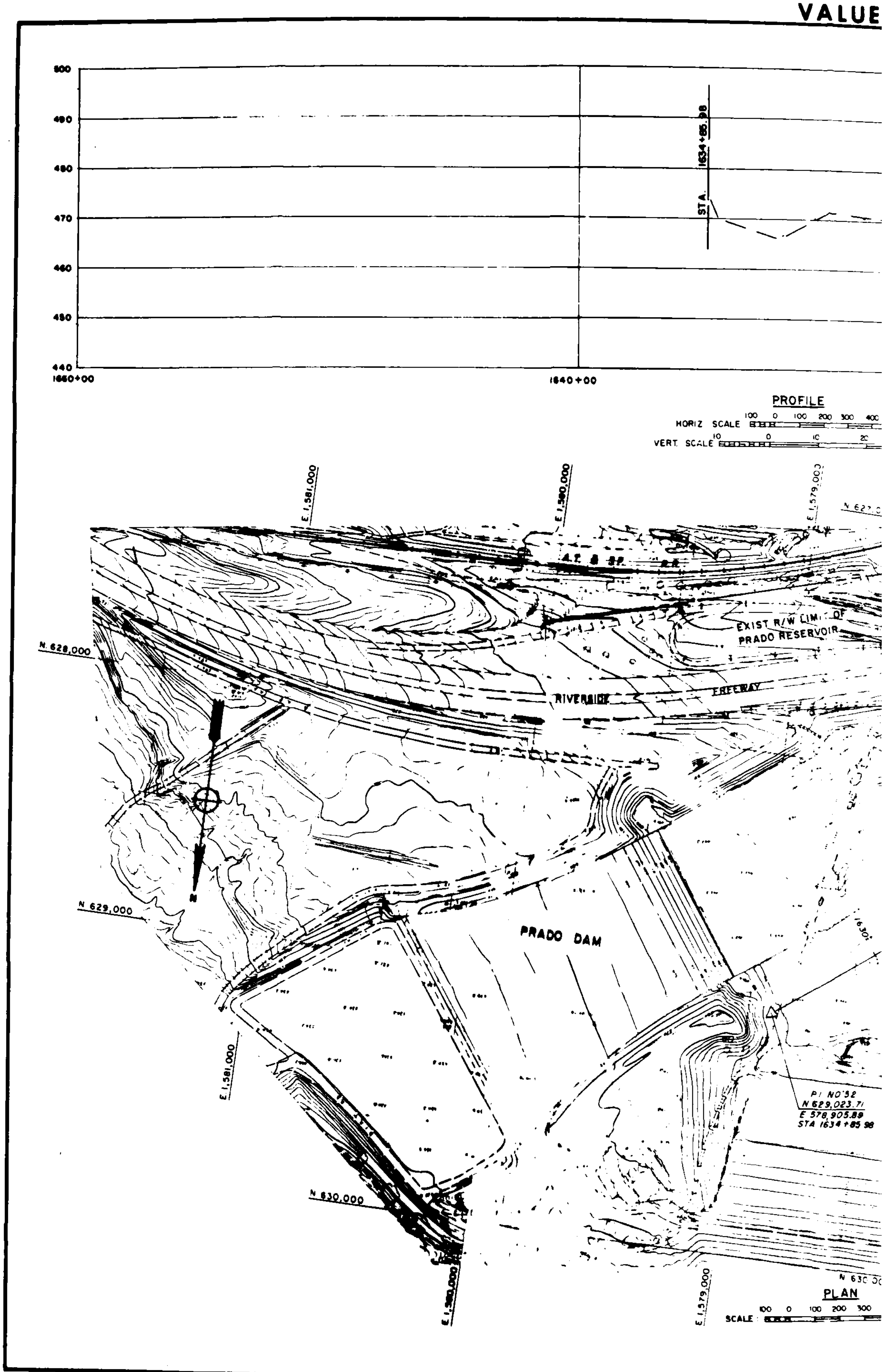
SAFETY PAYS

PLATE 3

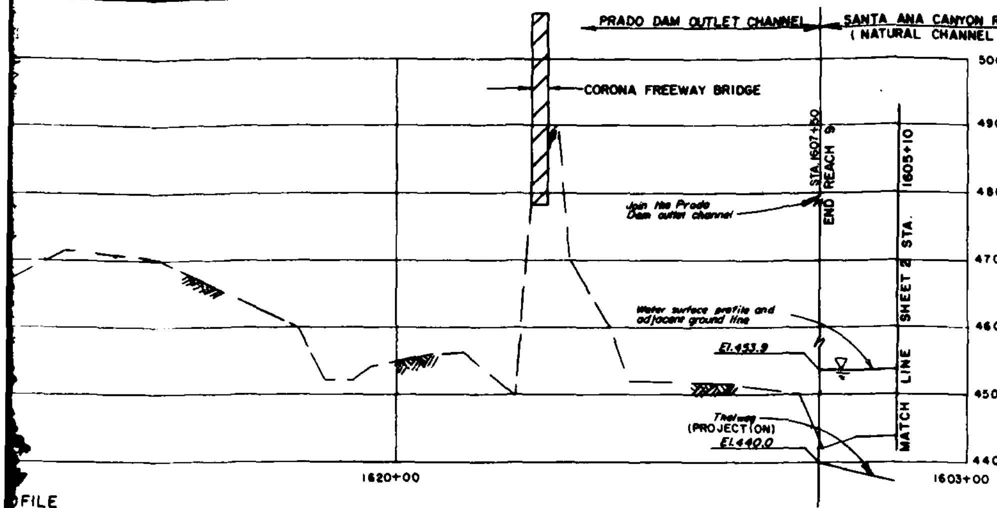
2

ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING

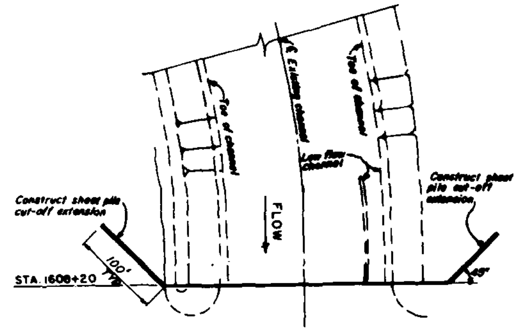
VALUE



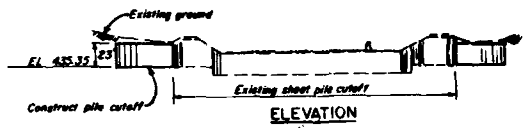
VALUE ENGINEERING PAYS



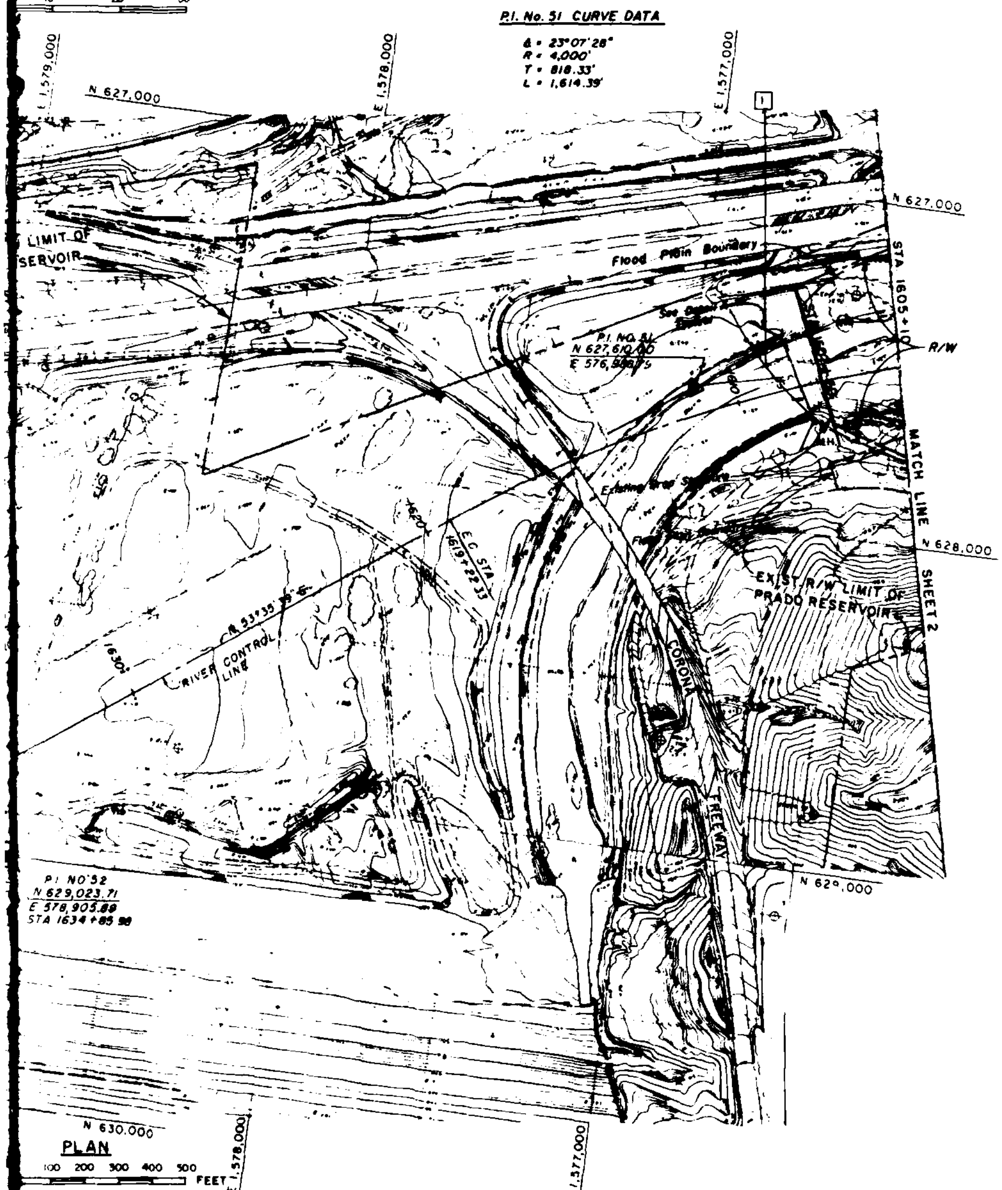
PROFILE



PLAN



ELEVATION
DETAIL - A
EXISTING DROP STRUCTURE
NOT TO SCALE



PLAN

HYDRAULIC ELEMENTS									
STATION	DISCHARGE								
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.EL.	Q
1607+50	.050	.043	.050	3.64	10.50	3.31	13.61	463.61	31,000

LEGEND

EQUESTRIAN / HIKING TRAIL

NEW BIKE TRAIL

NO UTILITY, SEE SHEET 62 FOR TABULATION

NOTE:
SEE SHEET 3 FOR TYPICAL TRAIL DETAILS.

PHOTOGRAPHED JUNE 1987 (SHEETS 2 THRU 8)
BY PICTURE SCIENCES, INC.

PHOTOGRAPHED AUGUST 5, 1982 (SHEETS 1 AND 9 THRU 56)
BY: VARA SYSTEMS, INC.
WESTLAKE, CALIFORNIA

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: xBa
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA.1605+10 TO STA.1607+50

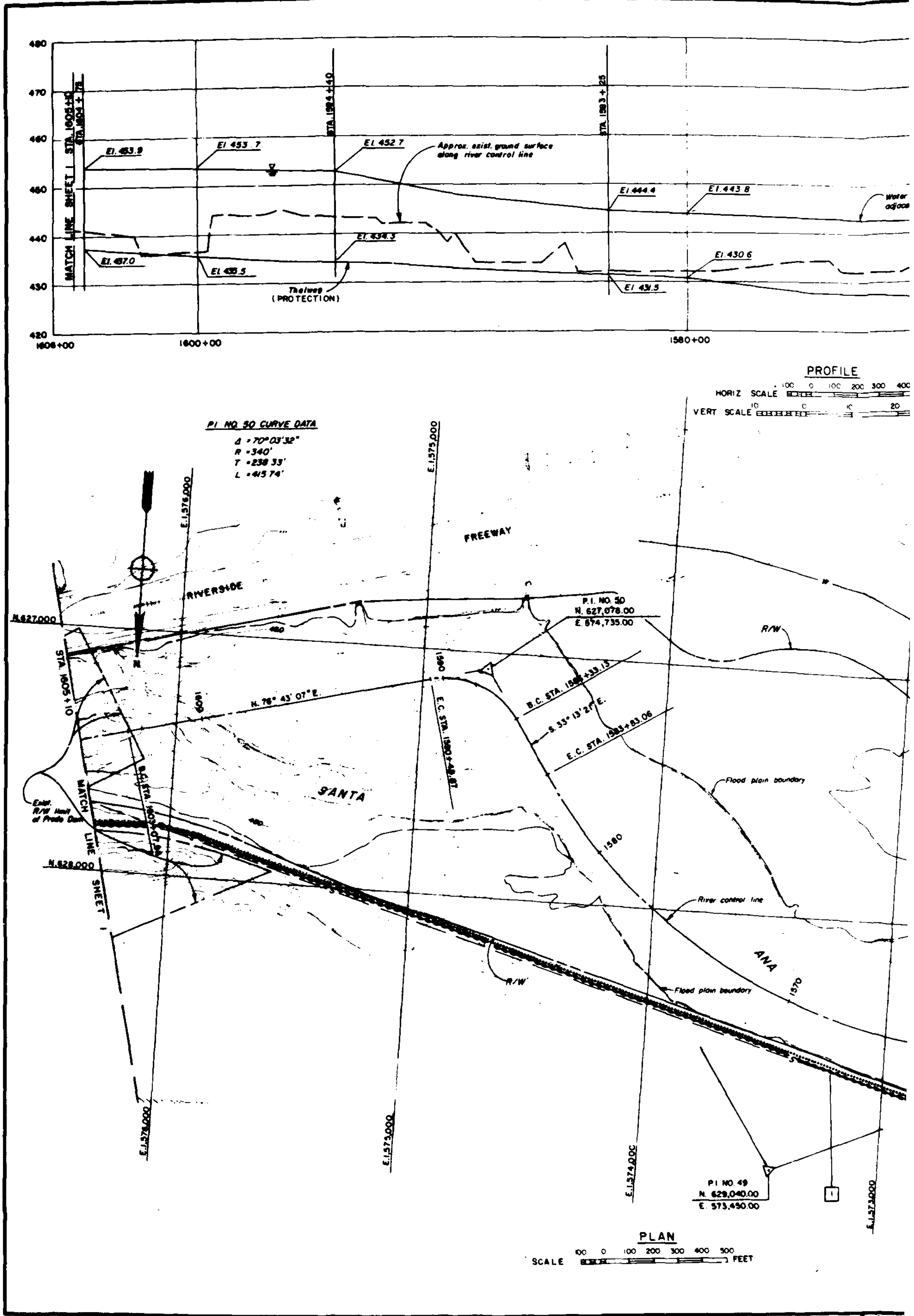
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 1 OF 100

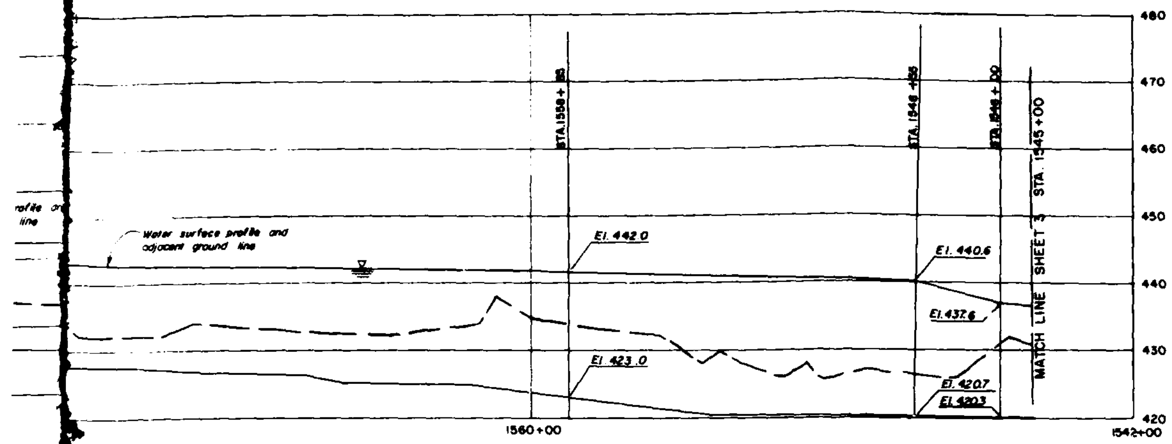
PLATE 4

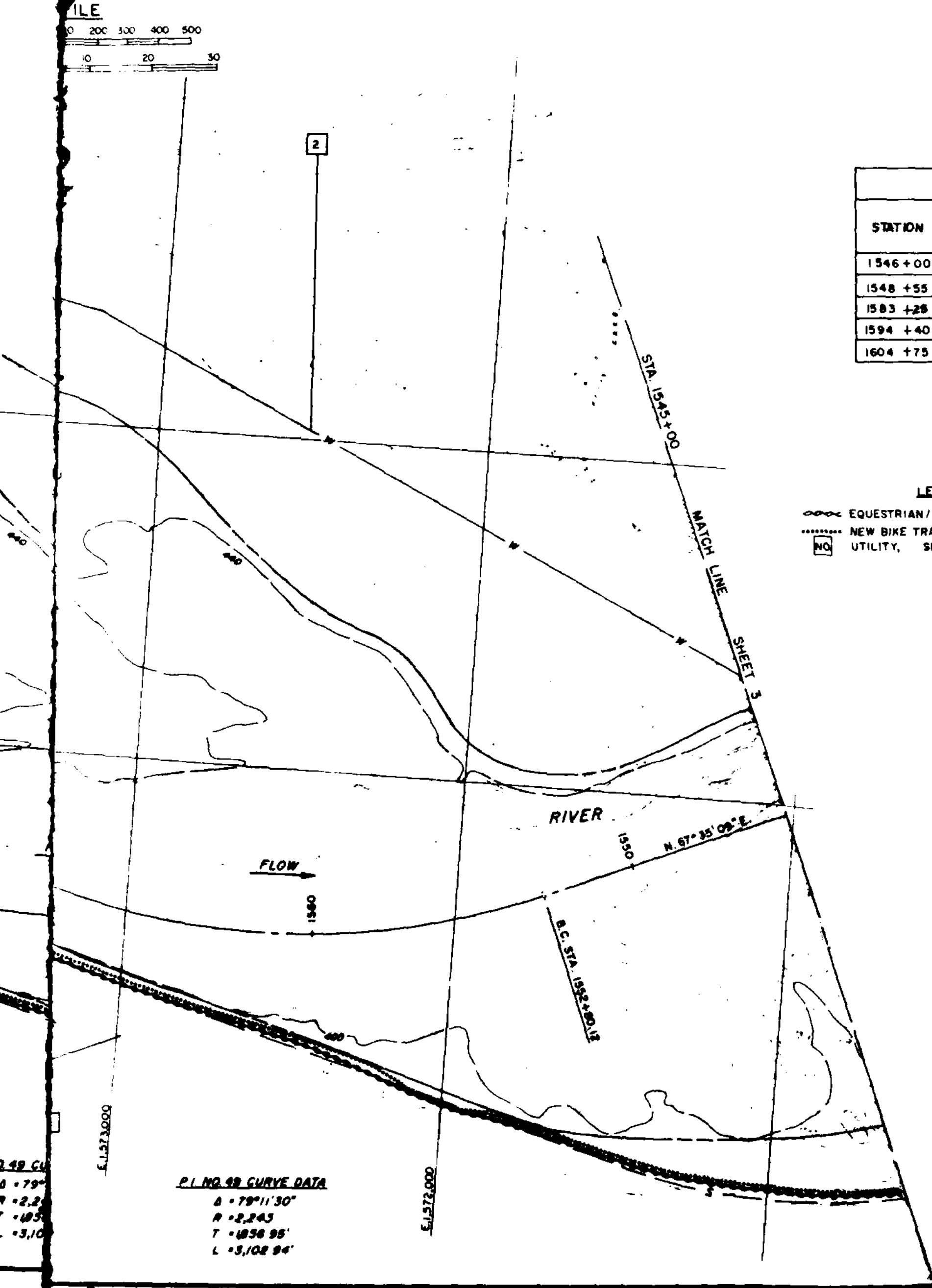
SAFETY PAYS

2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING







HYDRAULIC ELEMENTS									
STATION	DISCHARGE								
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.EL	Q
1546 +00	—	.030	043	0	14.56	2.67	17.26	437.56	33,400
1548 +55	—	.042	094	0	8.90	2.77	19.91	440.61	33,400
1583 +25	.05	016	070	.51	6.09	2.82	12.90	444.40	32,000
1594 +40	.082	.042	.05	1.30	6.04	1.87	18.41	452.71	32,000
1604 +75	10	.042	.10	2.39	6.14	0.91	16.89	453.89	31,000

LEGEND

- EQUESTRIAN / HIKING TRAIL
- NEW BIKE TRAIL
- NO UTILITY, SEE SHEET 62 FOR TABULATION

NOTE:
SEE SHEET 3 FOR TYPICAL TRAIL DETAILS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:

DRAWN BY: DRV

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA.1545+00 TO STA.1605+10

SUBMITTED BY:

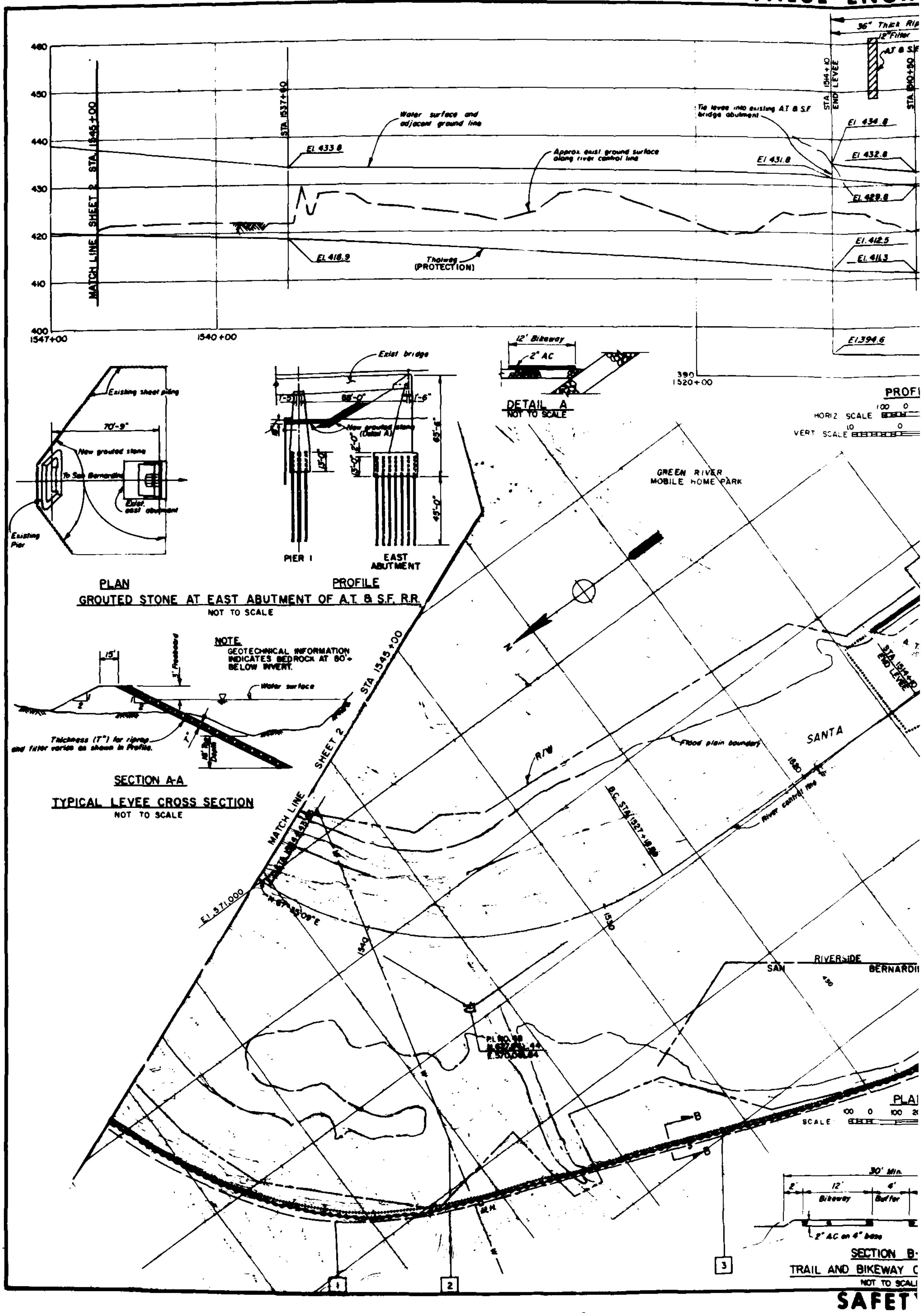
DATE APPROVED:

DISTRICT FILE NO

SHEET 2 OF 105 SHEETS

PLATE 6

VALUE ENGIN



SAFET

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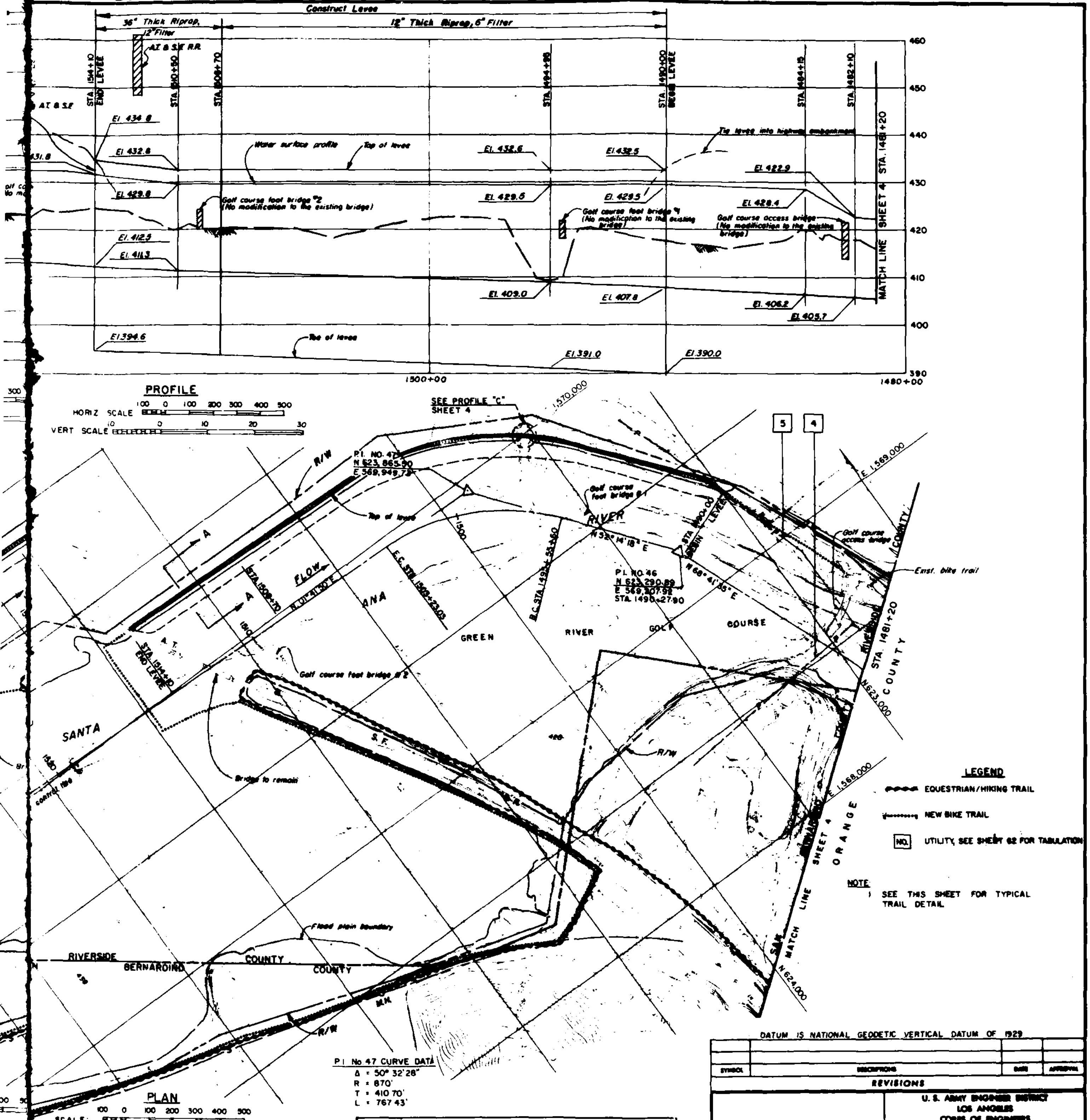
VALUE ENGINEERING PAYS



LEGEND

EQUESTRIAN/HIKING TRAIL

NEW BIKE TRAIL

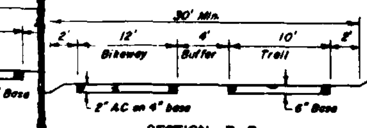
NO. UTILITY, SEE SHEET 62 FOR TABULATION

NOTE:

1 SEE THIS SHEET FOR TYPICAL TRAIL DETAIL

P.I. No 47 CURVE DATA
Δ = 50° 32' 28"
R = 870'
T = 410.70'
L = 767.43'

HYDRAULIC ELEMENTS									
STATION	DISCHARGE								
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.E.L	Q
1482+10	.036	.027	.036	5.04	14.01	5.35	16.99	422.89	34,500
1484+15	.035	.027	.035	3.64	8.36	3.94	22.22	429.48	33,800
1494+95	.036	.027	.036	1.87	6.29	2.87	21.70	429.80	33,800
1510+60	.036	.027	.036	4.66	10.96	3.09	16.54	429.84	33,800
1515+10	.070	.050	.036	1.73	8.86	2.22	19.56	432.36	33,800
1537+60	.070	.030	.046	1.96	14.11	4.86	14.90	433.80	33,400



SECTION B-B
TRAIL AND BIKEWAY COMBINATION
NOT TO SCALE

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: PENUELETA

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1481+20 TO STA. 1545+00

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

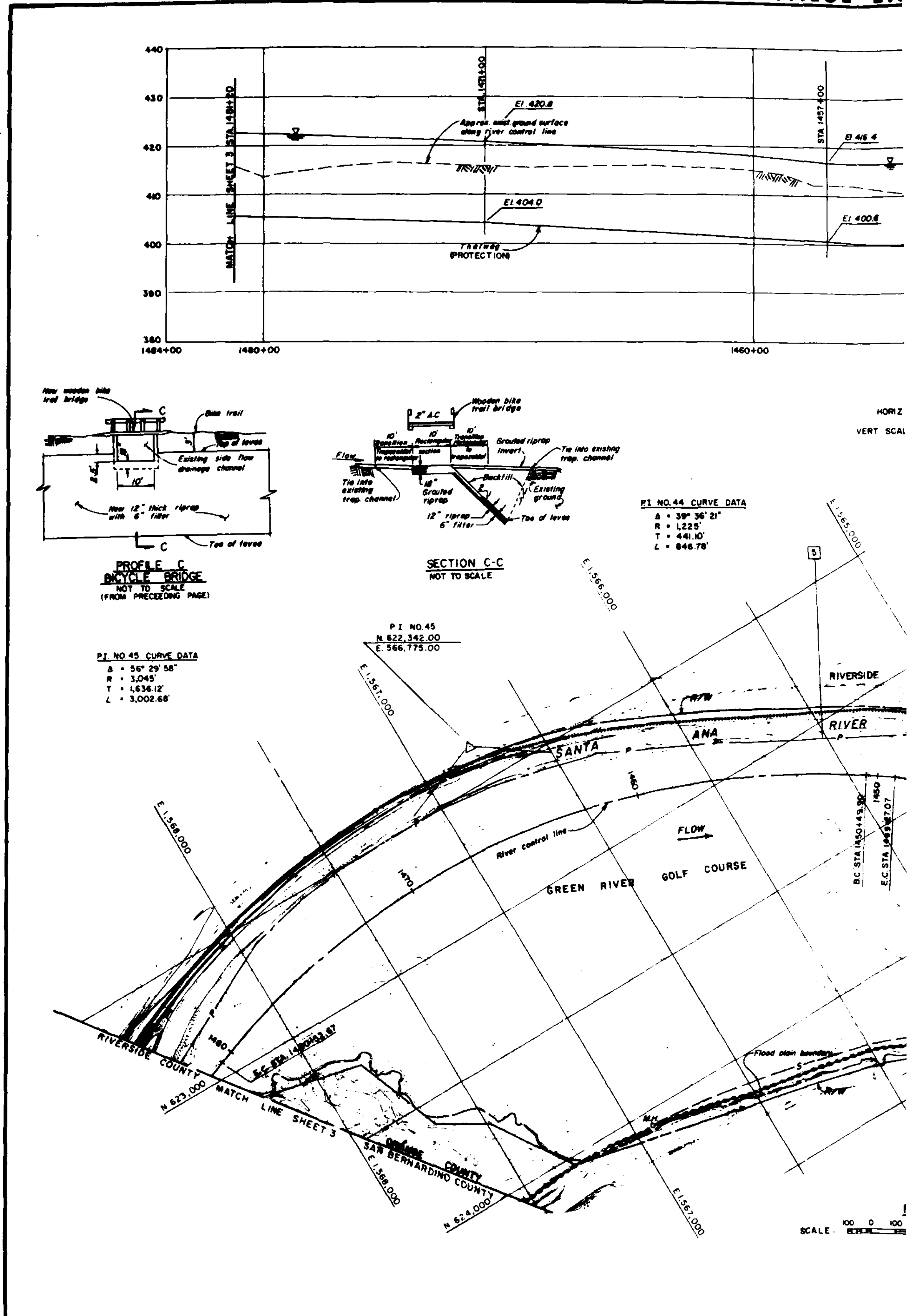
SHEET 3 OF 100

SAFETY PAYS

2

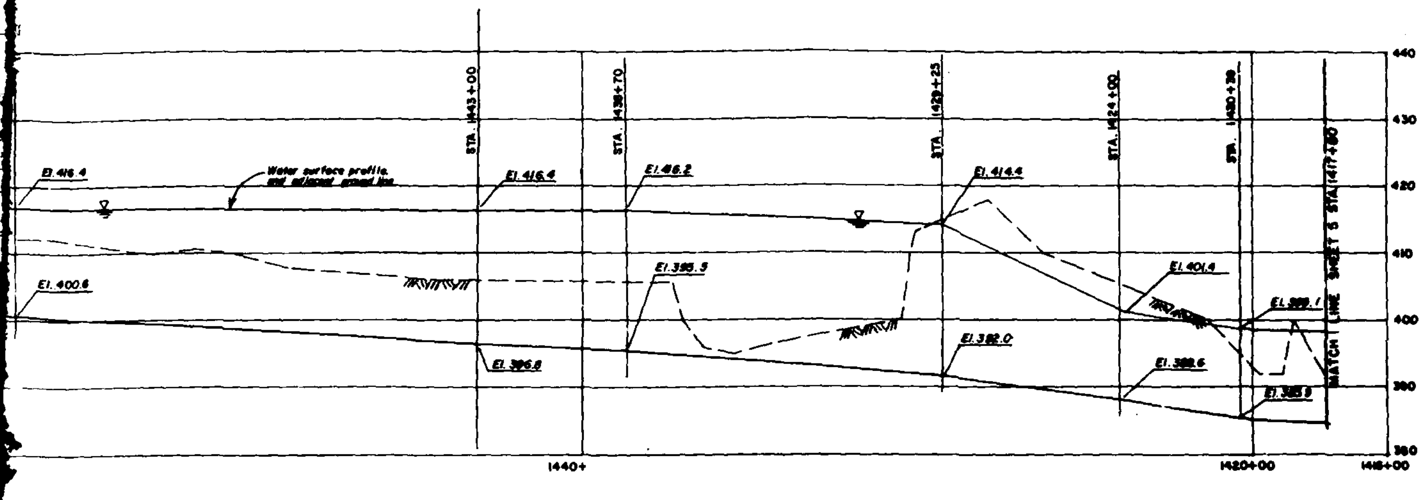
VALUE EN

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



SAF

UE ENGINEERING PAYS



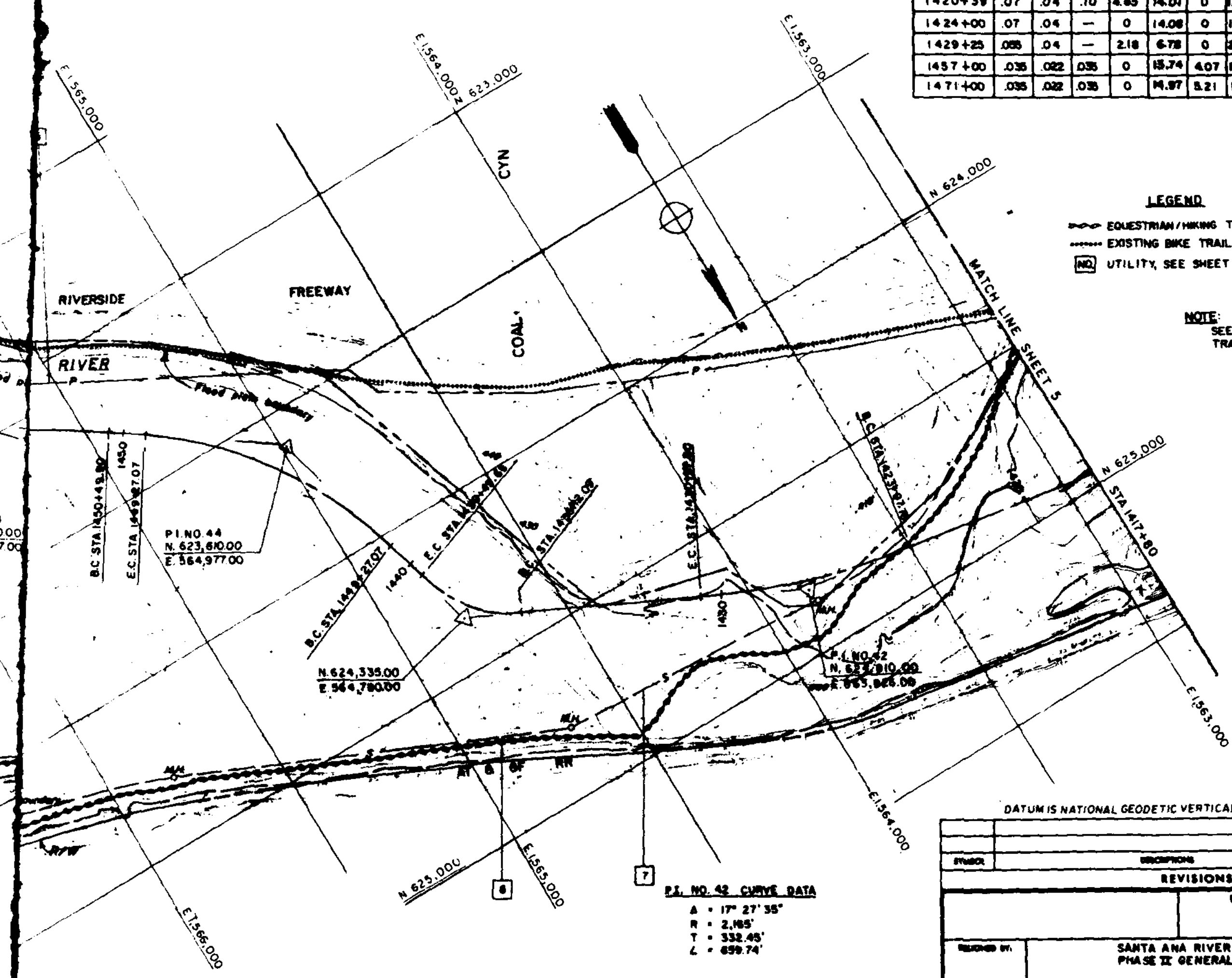
PROFILE

HORIZ SCALE 100 0 100 200 300 400 500

VERT SCALE 10 0 10 20 30

STATION	DISCHARGE									
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.EL	Q
1420+39	.07	.04	.10	4.85	14.01	0	13.15	399.05	35,000
1424+00	.07	.04	—	0	14.08	0	12.84	401.44	35,000
1429+25	.055	.04	—	2.18	6.78	0	22.41	414.41	35,000
1457+00	.035	.022	.035	0	15.74	4.07	15.83	416.43	34,500
1471+00	.035	.022	.035	0	14.97	5.21	16.79	420.79	34,500

HYDRAULIC ELEMENTS



LEGEND

EQUESTRIAN/HIKING TRAIL.

EXISTING BIKE TRAIL

[NO] UTILITY, SEE SHEET 62 FOR TABULATION.

NOTE: SEE SHEET 3 FOR TYPICAL TRAIL DETAILS.

P.I. NO. 42 CURVE DATA
Δ = 17° 27' 35"
R = 2,165'
T = 332.45'
L = 659.74'

PLAN

SCALE 100 0 100 200 300 400 500 FEET

P.I. NO. 43 CURVE DATA
Δ = 48° 21' 12"
R = 400'
T = 179.57'
L = 337.57'

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:

DRAWN BY: LBA

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL PLAN AND PROFILE STA. 1417+80 TO STA. 1481+20

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

SHEET 4 OF 108 SHEETS

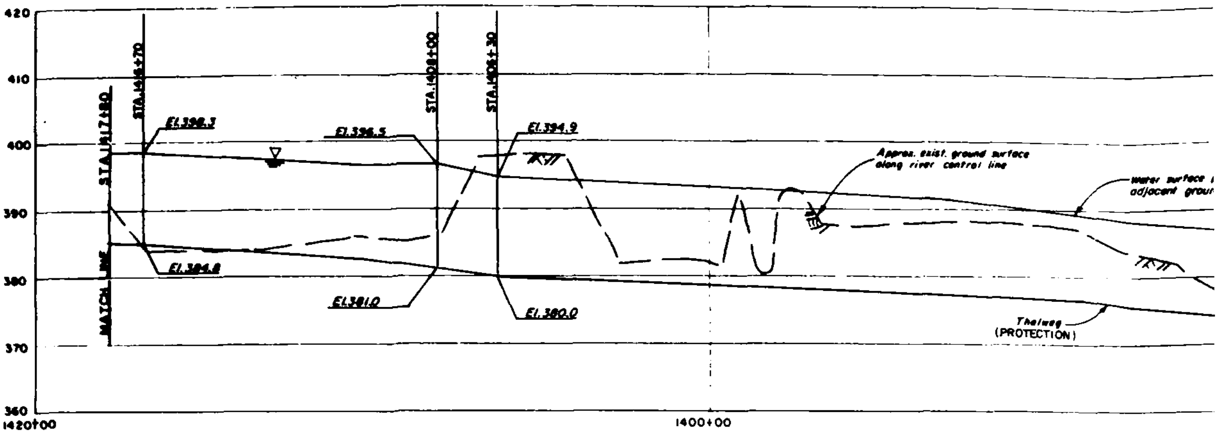
PLATE 7

SAFETY PAYS

2

VALUE ENG

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



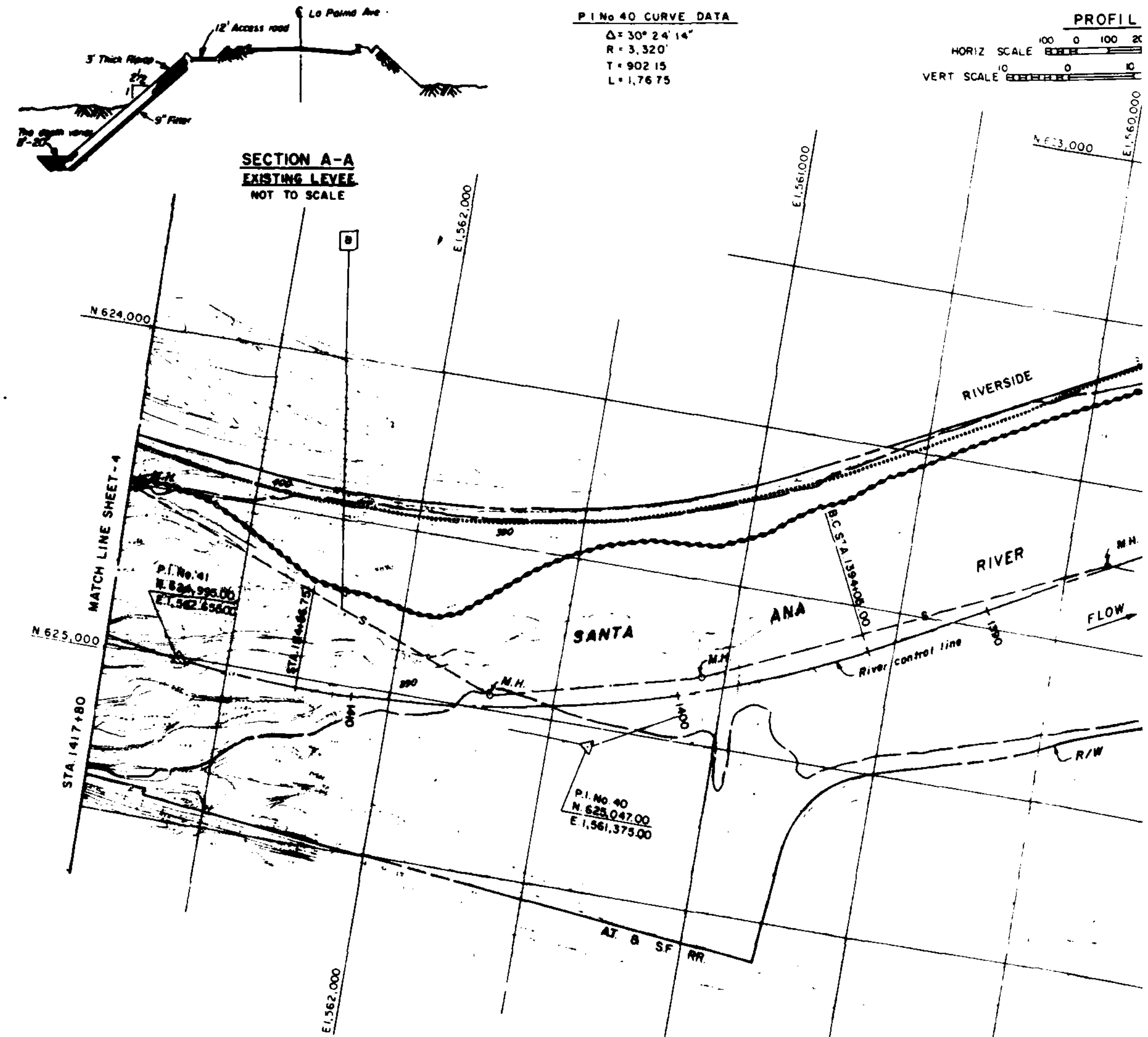
PROFIL

HORIZ SCALE

VERT SCALE

P I No 40 CURVE DATA

Δ = 30° 24' 14"
R = 3,320'
T = 902.15
L = 1,76 75



STATION	DISCHARGE								
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.El.	Q
1355+70	.084	.040	.050	2.06	8.76	4.54	13.22	372.02	35,800
1379+80	.10	.040	.070	4.41	13.10	4.67	12.78	384.58	35,500
1406+30	.10	.04	.070	2.67	11.91	2.25	14.85	394.85	35,500
1408+00	.10	.04	.08	.61	7.46	1.45	15.52	396.52	35,500
1416+70	.07	.04	.10	4.01	9.73	.23	13.51	398.31	35,000

LEGEND

EQUESTRIAN/HIKING TRAIL

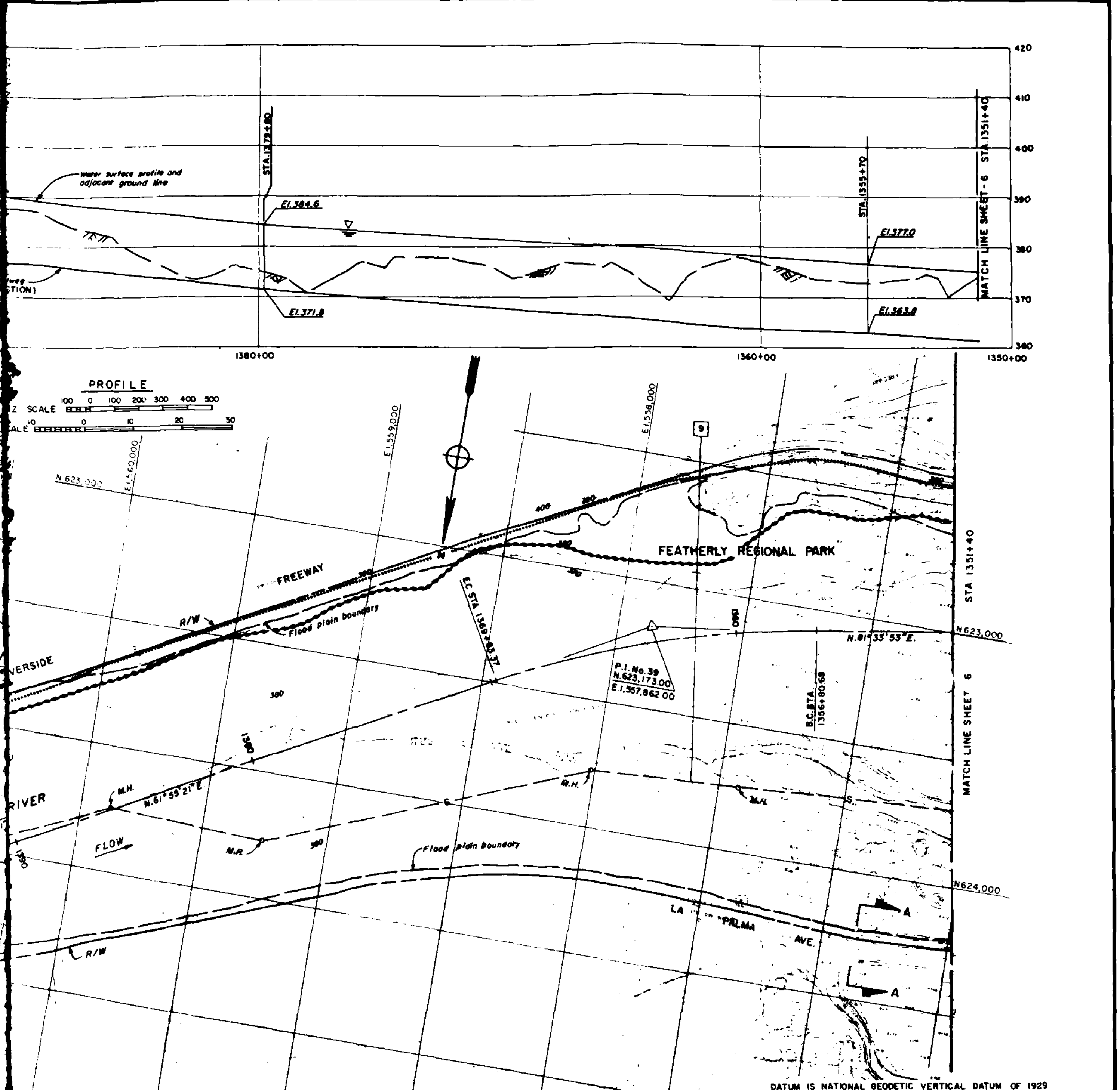
EXISTING BIKE TRAIL

UTILITY SEE SHEET 62 FOR TABULATION

PLAN

SCALE

SAFE



NOTE: SEE SHEET 3 FOR TYPICAL TRAIL DETAILS.

P.I. No 39 CURVE DATA

Δ = 19°38' 32"
R = 3800'
T = 657.82'
L = 1302.72'

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

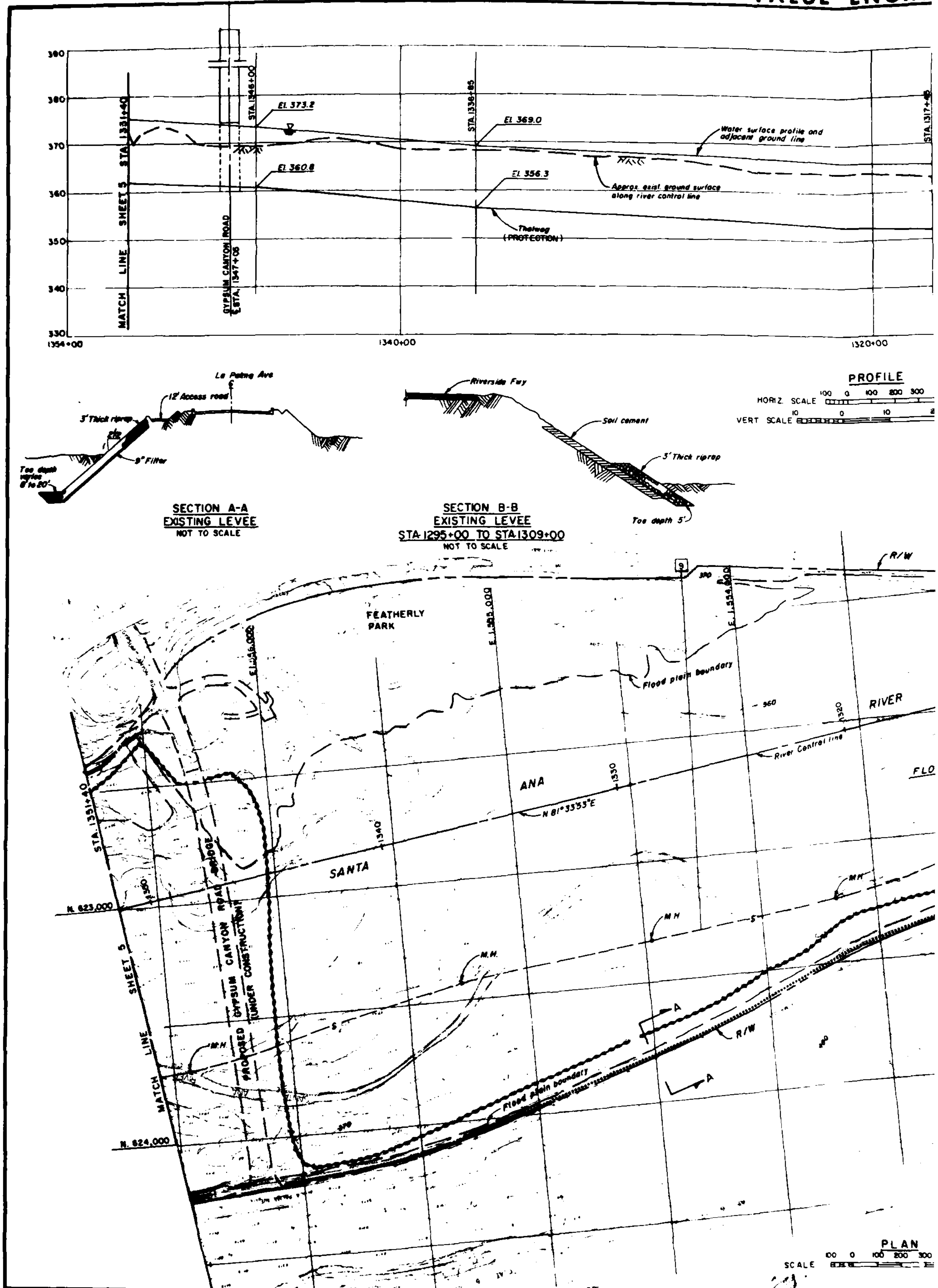
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA.1351+40 TO STA.1417+80

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 5 OF 108
PLATE 8

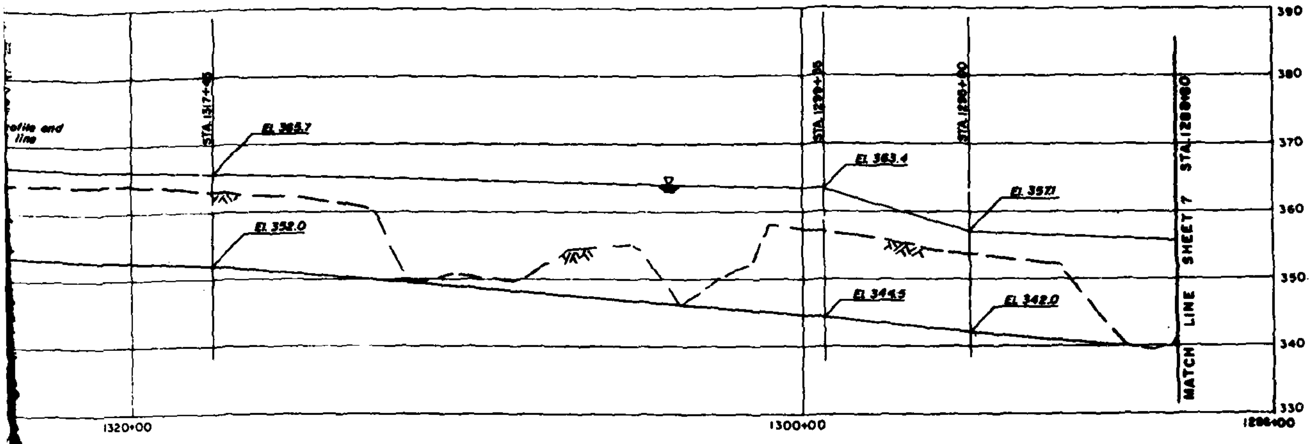
VALUE ENGIN



SAFETY

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

ALUE ENGINEERING PAYS



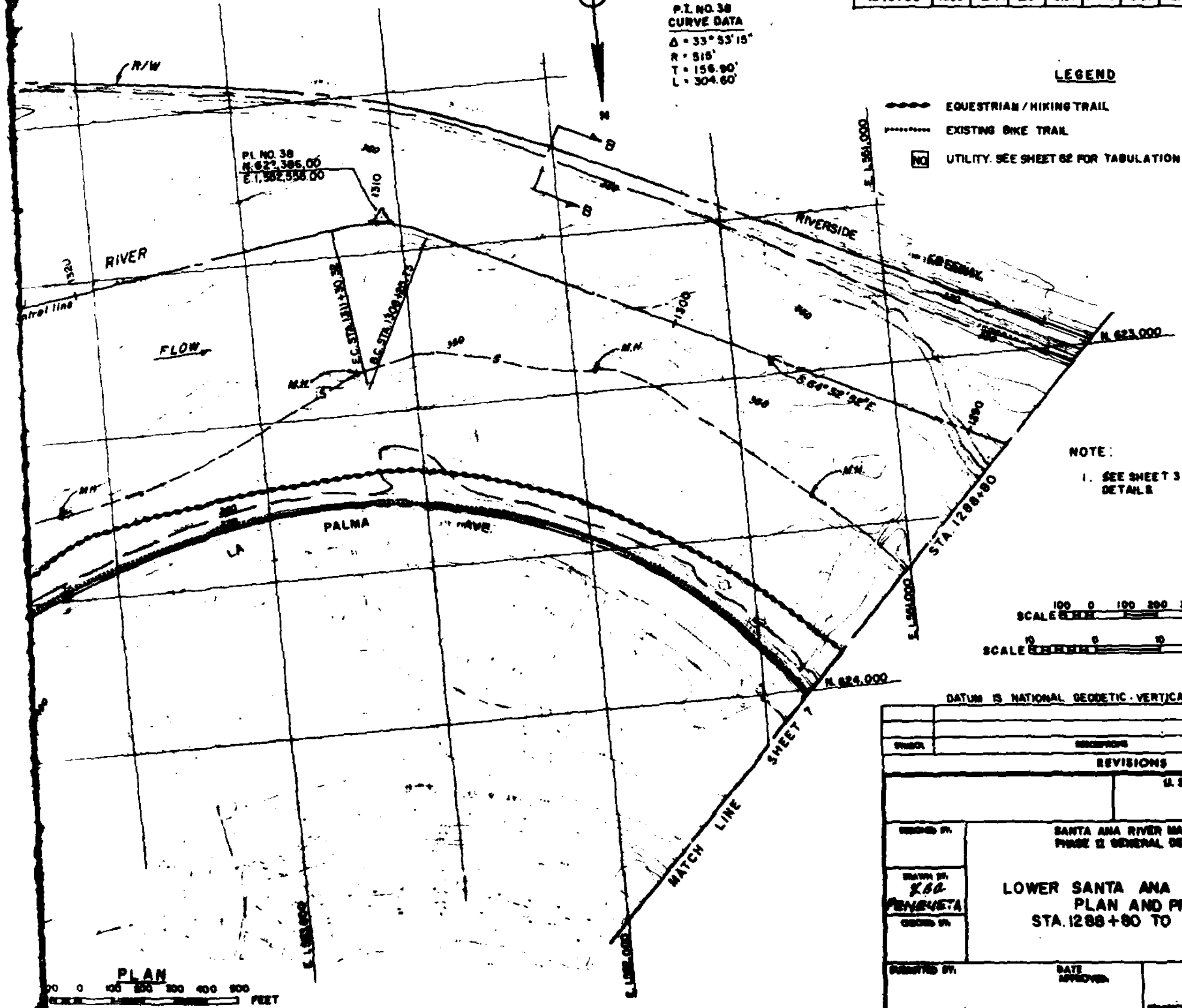
PROFILE

SCALE 100 0 100 200 300 400 500

0 10 20 30

STATION	DISCHARGE								
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.EL	Q
1296+00	.05	.04	.093	0	10.47	1.96	15.09	367.09	38,000
1299+35	.06	.04	.077	0	7.86	2.20	16.90	368.40	36,000
1317+45	.073	.04	.06	3.11	8.64	5.63	13.74	365.74	36,000
1336+65	.063	.04	.10	4.05	10.73	3.82	12.79	[illegible]	38,000
1346+00	.069	.044	.06	3.67	10.88	3.87	12.41	373.21	35,800

HYDRAULIC ELEMENTS



LEGEND

EQUESTRIAN / HIKING TRAIL

EXISTING BIKE TRAIL

NO UTILITY. SEE SHEET 62 FOR TABULATION

NOTE:

1. SEE SHEET 3 FOR TYPICAL TRAIL DETAILS

SCALE 100 0 100 200 300 400 500 FEET

SCALE 10 0 10 20 30 FEET

PLAN

100 0 100 200 300 400 500 FEET

DATUM IS NATIONAL GEODETIC-VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: Z.6.a PENUELA

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1288+80 TO STA. 1351+40

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

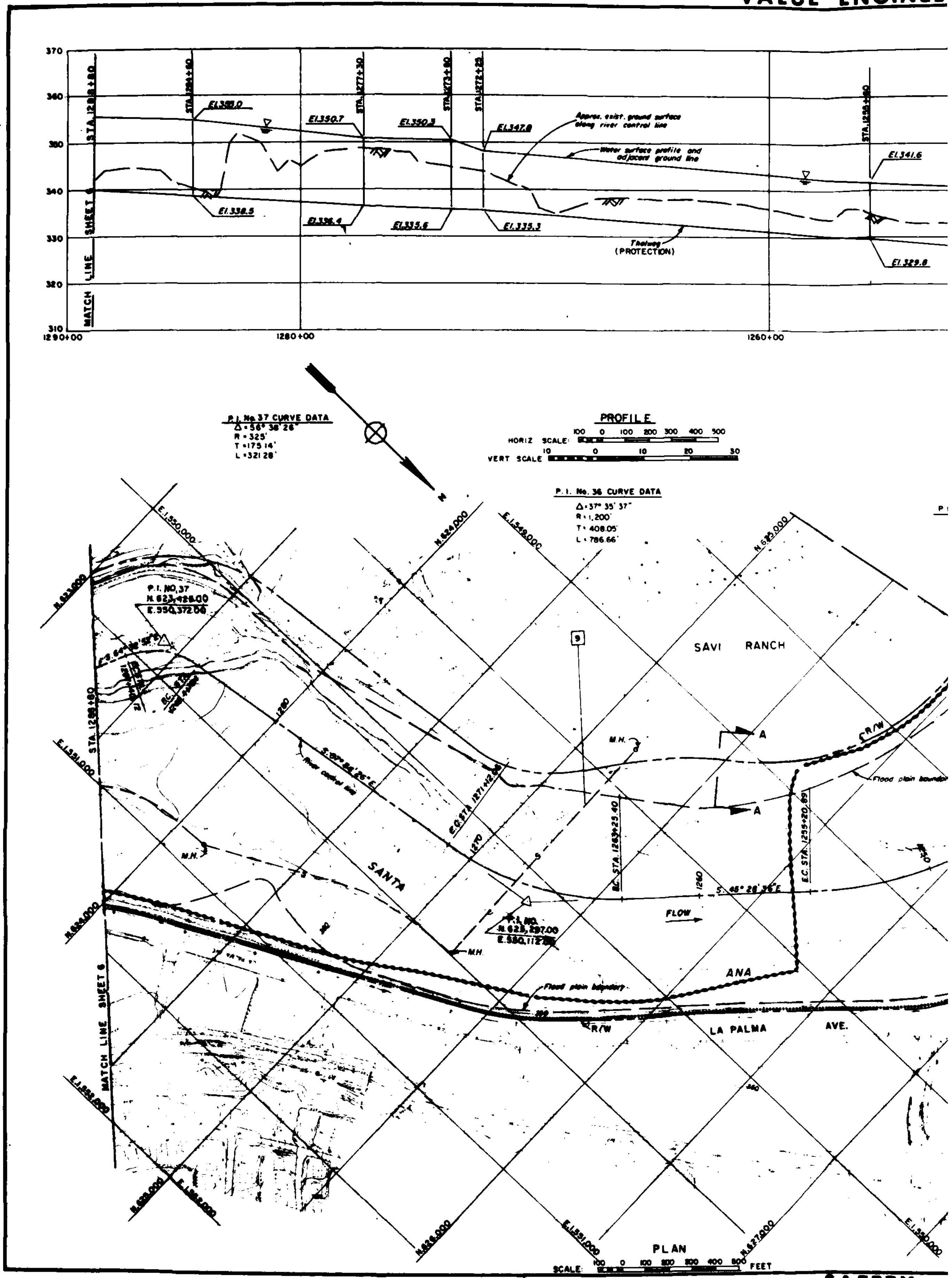
SHEET 8 OF 109 SHEETS

PLATE

SAFETY PAYS

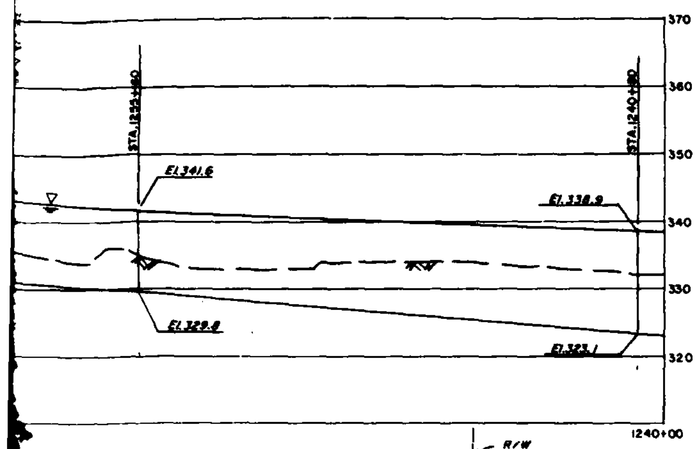
2

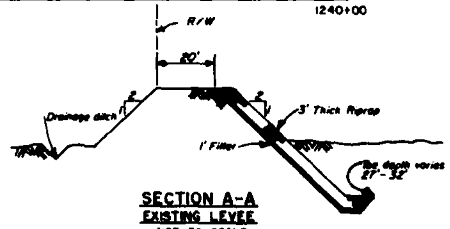
VALUE ENGINEE



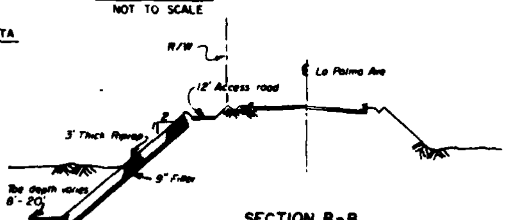
SAFETY

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

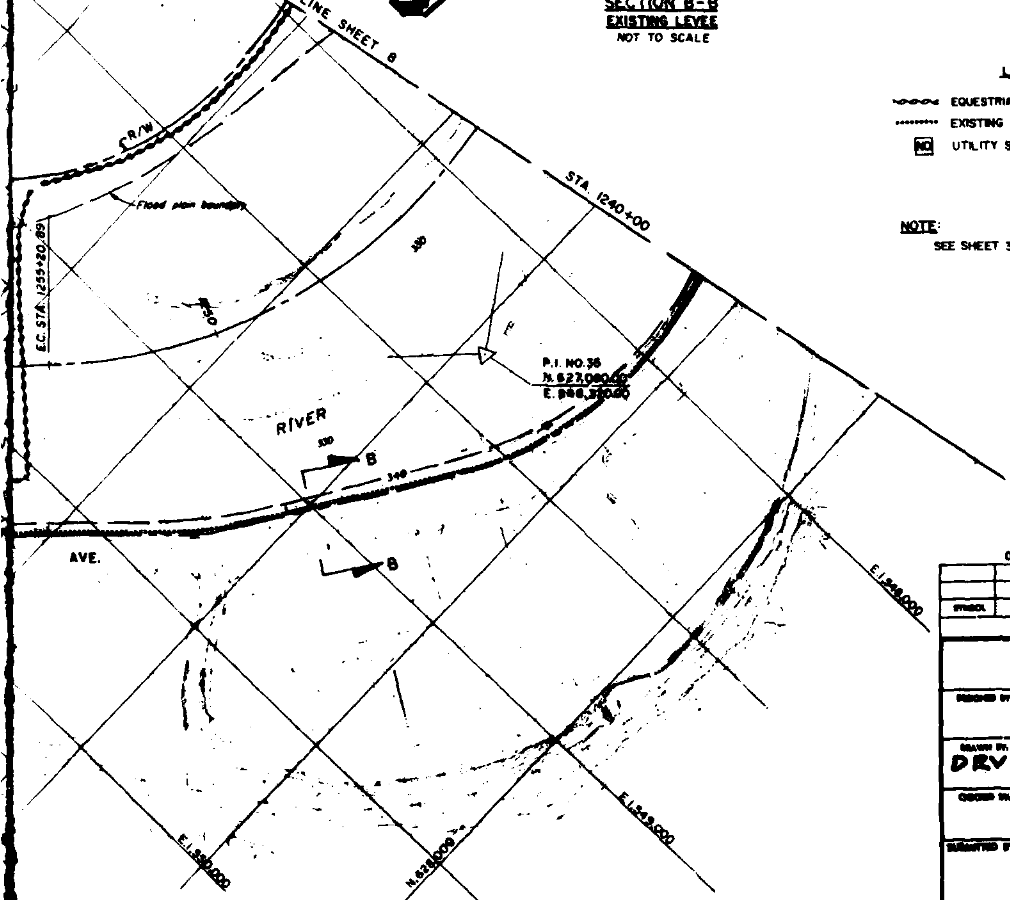




SECTION A-A
EXISTING LEVEE
NOT TO SCALE



SECTION B-B
EXISTING LEVEE
NOT TO SCALE



STATION	DISCHARGE								
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.EL	Q
1240+80	.070	.035	.050	1.67	5.91	3.56	15.78	336.88	36,500
1255+60	.050	.035	.070	4.83	10.77	4.09	11.81	341.81	36,500
1272+25	.050	.040	.099	7.08	15.25	2.27	12.80	342.80	36,500
1273+60	.050	.040	.093	5.35	9.47	1.67	14.69	350.29	36,500
1277+30	.050	.040	.095	4.27	12.71	1.61	14.27	350.67	36,500
1284+60	.050	.040	.091	4.39	7.23	0.57	16.49	354.39	36,000

Table title: HYDRAULIC ELEMENTS

LEGEND

- EQUESTRIAN/HIKING TRAIL
- EXISTING BIKE TRAIL
- NO UTILITY SEE SHEET 62 FOR TABULATION

NOTE:
SEE SHEET 3 FOR TYPICAL TRAIL DETAILS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

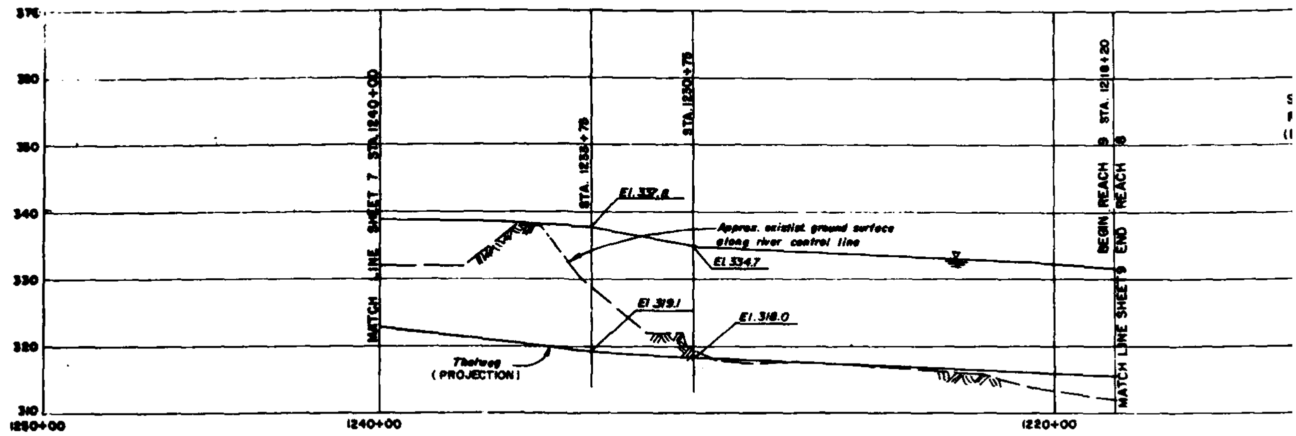
SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:
DRAWN BY: DRV
CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1240+00 TO STA. 1288+80

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 7 OF 108 SHEETS
PLATE 10

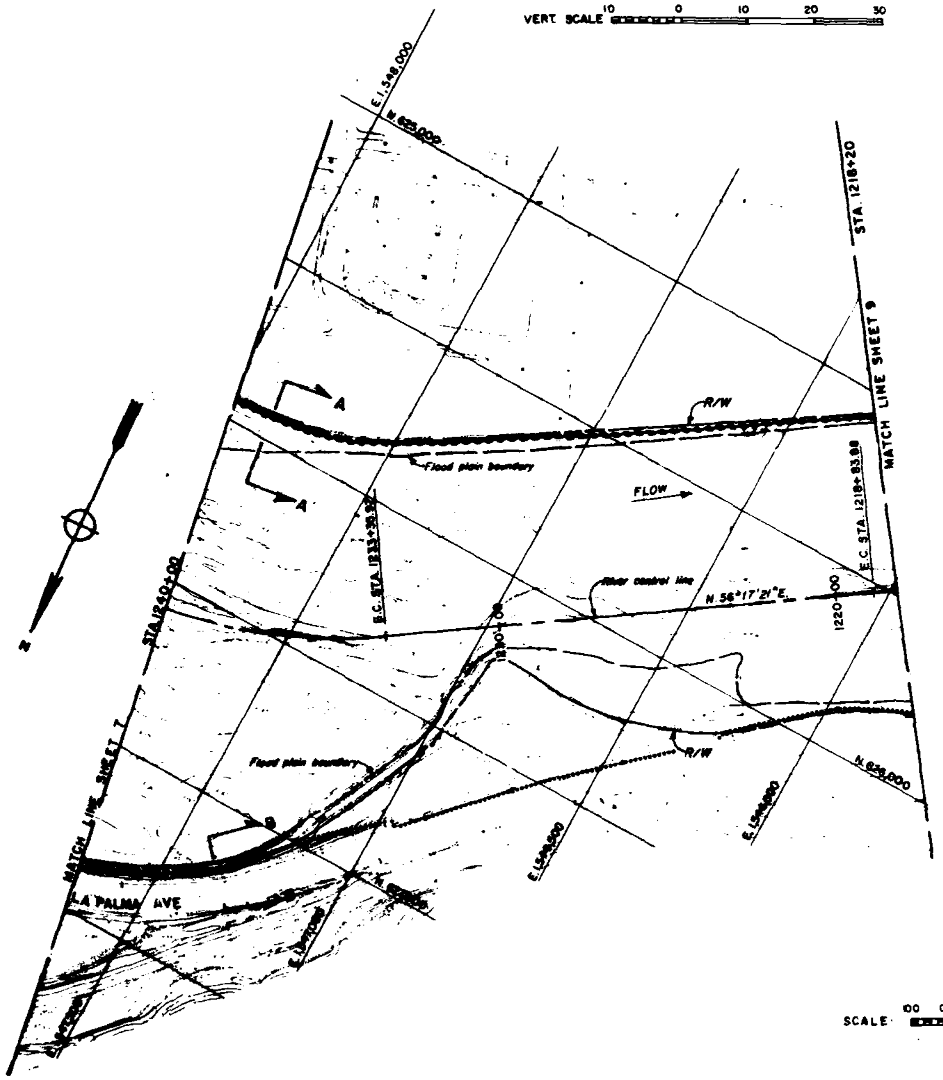
2



PROFILE

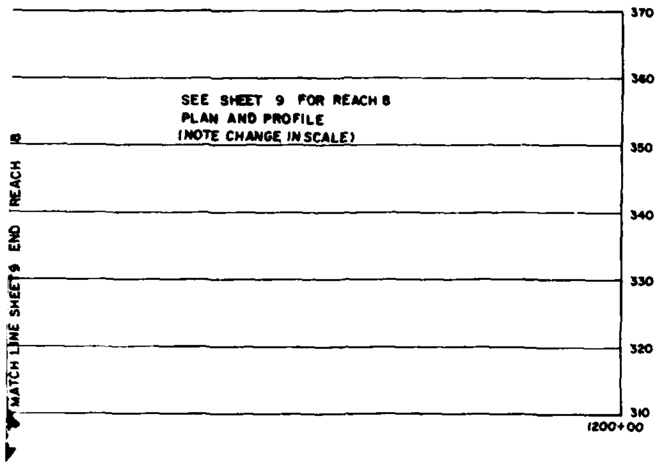
HORIZ. SCALE 100 0 100 200 300 400 500

VERT. SCALE 10 0 10 20 30



PLAN

SCALE 100 0 100 200 300



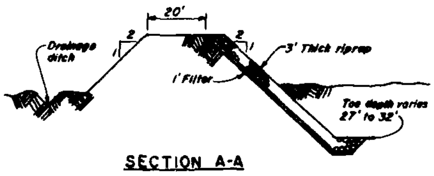
HYDRAULIC ELEMENTS									
STATION	DISCHARGE								
	N_{LOB}	N_{CH}	N_{ROB}	V_{LOB}	V_{CH}	V_{ROB}	D_{MAX}	W.S.EL	Q
1216+40	.061	.035	.060	1.28	12.70	3.34	16.37	330.70	37,000
1230+75	.070	.035	.070	2.30	13.32	4.12	16.71	334.71	36,500
1233+75	.067	.043	.070	2.45	7.71	4.16	[illegible]	[illegible]	36,500

LEGEND

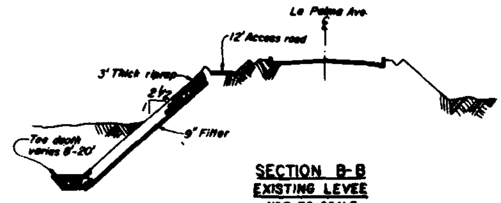
- EQUESTRIAN/HIKING TRAIL
- EXISTING BIKE TRAIL
- No UTILITY. SEE SHEET 62 FOR TABULATION

NOTE:

1. SEE SHEET 3 FOR TYPICAL TRAIL DETAILS.

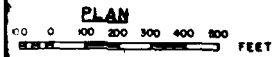


SECTION A-A
EXISTING LEVEE
NOT TO SCALE



SECTION B-B
EXISTING LEVEE
NOT TO SCALE

PLAN



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

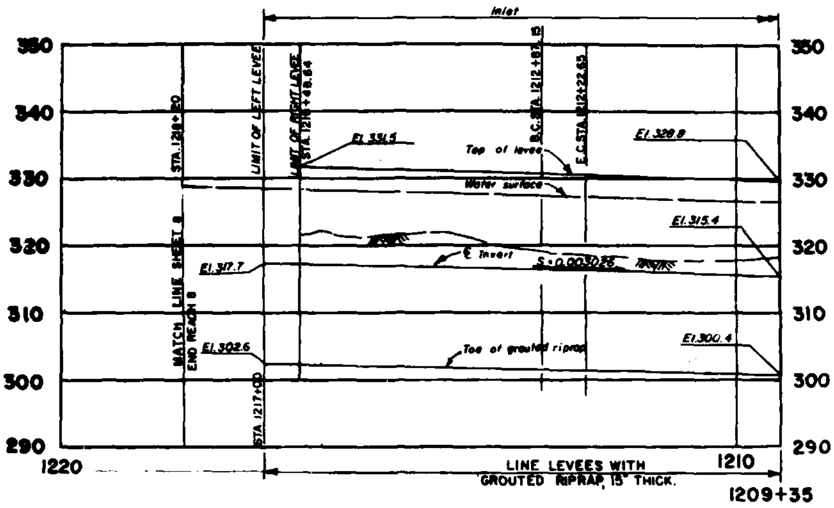
DRAWN BY: DRV

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1218+20 TO STA. 1240+00

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 8 OF 100

PLATE 11

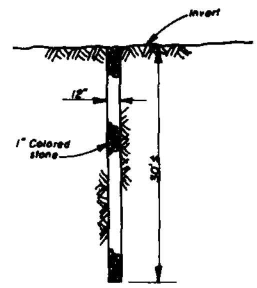
2



PROFILE

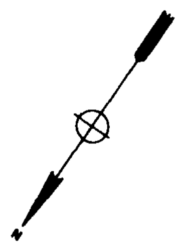
HORIZ. SCALE: 100 0 100 200 300 FEET

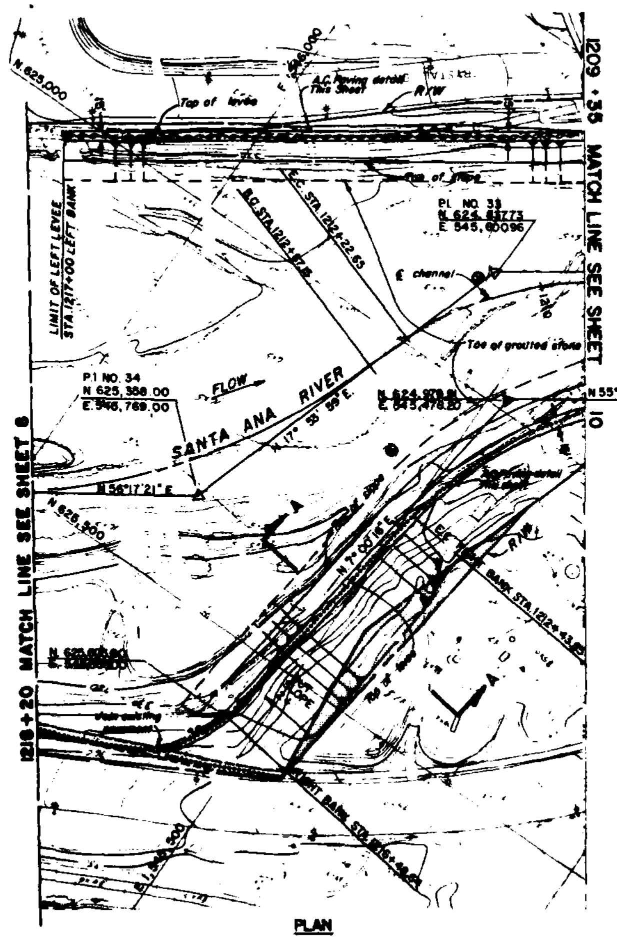
VERT. SCALE: 10 0 10 20 30 FEET



TYPICAL SCOUR GAGE DETAIL

NOT TO SCALE





PLAN

SCALE 100 0 100 200 300 FEET

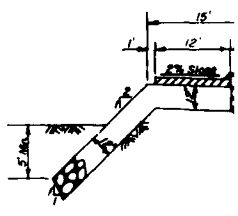
P.I. NO. 33
℄ CURVE DATA
Δ = 37° 20' 0"
R = 500'
T = 168.92'
L = 325'

P.I. NO. 34
℄ CURVE DATA
Δ = 36° 23' 22"
R = 900'
T = 313.32'
L = 603.02'

RT BANK CURVE DATA
Δ = 48° 27' 20"
R = 500'
T = 225'
L = 422.85'

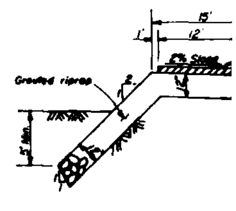
NOTE:

1. REMOVE EXISTING SIDE SLOPE PROTECTION (4' FACING STONE W/8" FILTER)
2. PLAN SCALE CHANGED BEGINNING ON THIS SHEET.



TYPICAL SIDE OVERFL

NOT TO SC



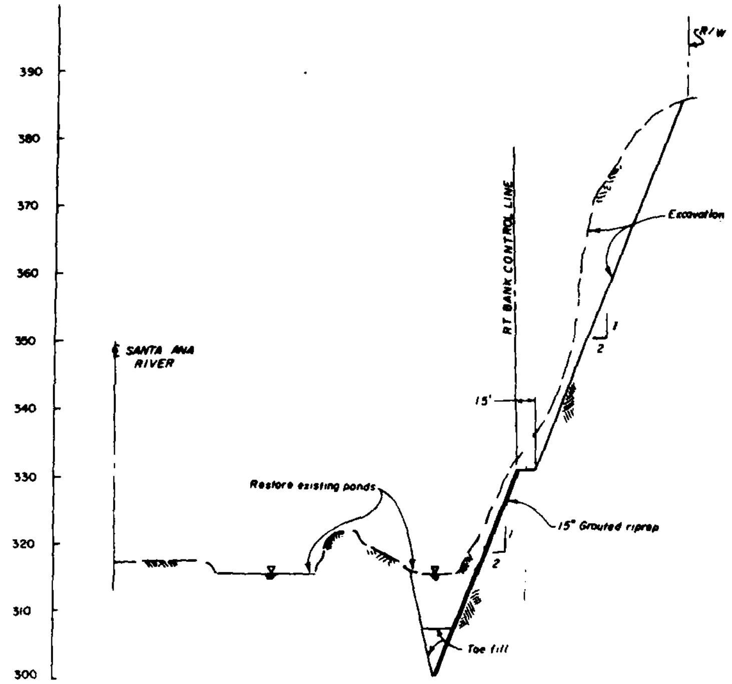
TYPICAL SIDE OVERFI

NOT TO SC

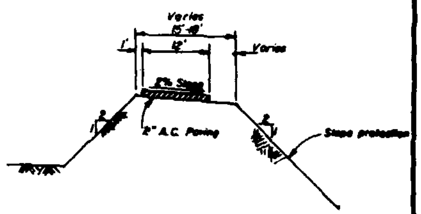
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

E ENGINEERING PAYS

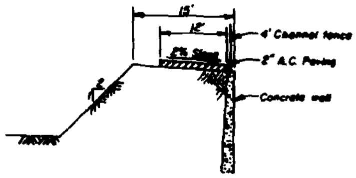
COUR GAGE DETAIL
OT TO SCALE



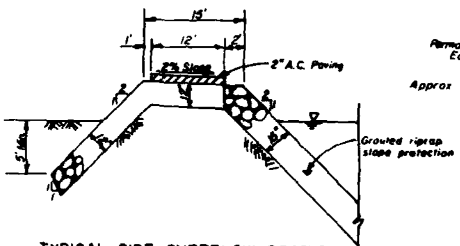
SECTION A-A
HOR 1" = 50'
VERT 1" = 10'



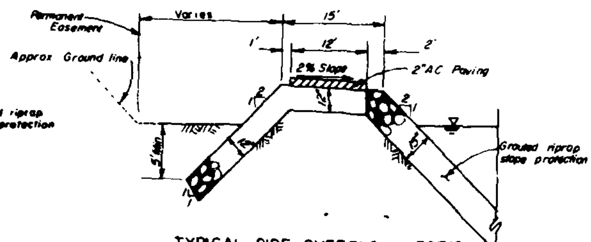
A.C. PAVEMENT SECTION
NOT TO SCALE



A.C. PAVEMENT SECTION
NOT TO SCALE



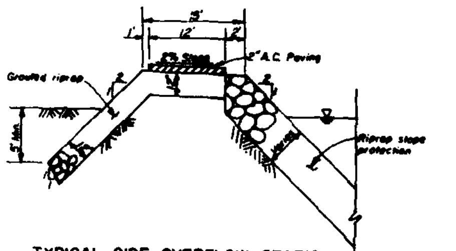
TYPICAL SIDE OVERFLOW SECTION
NOT TO SCALE



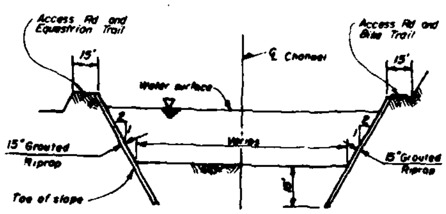
TYPICAL SIDE OVERFLOW SECTION
NOT TO SCALE

LEGEND

- EQUESTRIAN / HIKING TRAIL
- NEW ACCESS RD. AND BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- ADDITIONAL R/W REQUIRED
- ⊗ SCOUR GAGE SEE DETAIL THIS SHEET



TYPICAL SIDE OVERFLOW SECTION
NOT TO SCALE



TYPICAL X-SECTION
STA. 1209+35 TO STA. 1217+00 LT. BANK
STA. 1209+35 TO STA. 1216+48 RT. BANK
NOT TO SCALE

TA

SIDE SLOPE PROTECTION
W/8" FILTER)
GED BEGINNING

HYDRAULIC ELEMENTS									
STA TO STA		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .040			
						DA	VA	DA	VA
1217+00	1209+35	INLET	0.003026	37,000	VARIES	10.5	8.7	11.0	8.4

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: P. PENSUET
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1209+35 TO STA. 1218+20

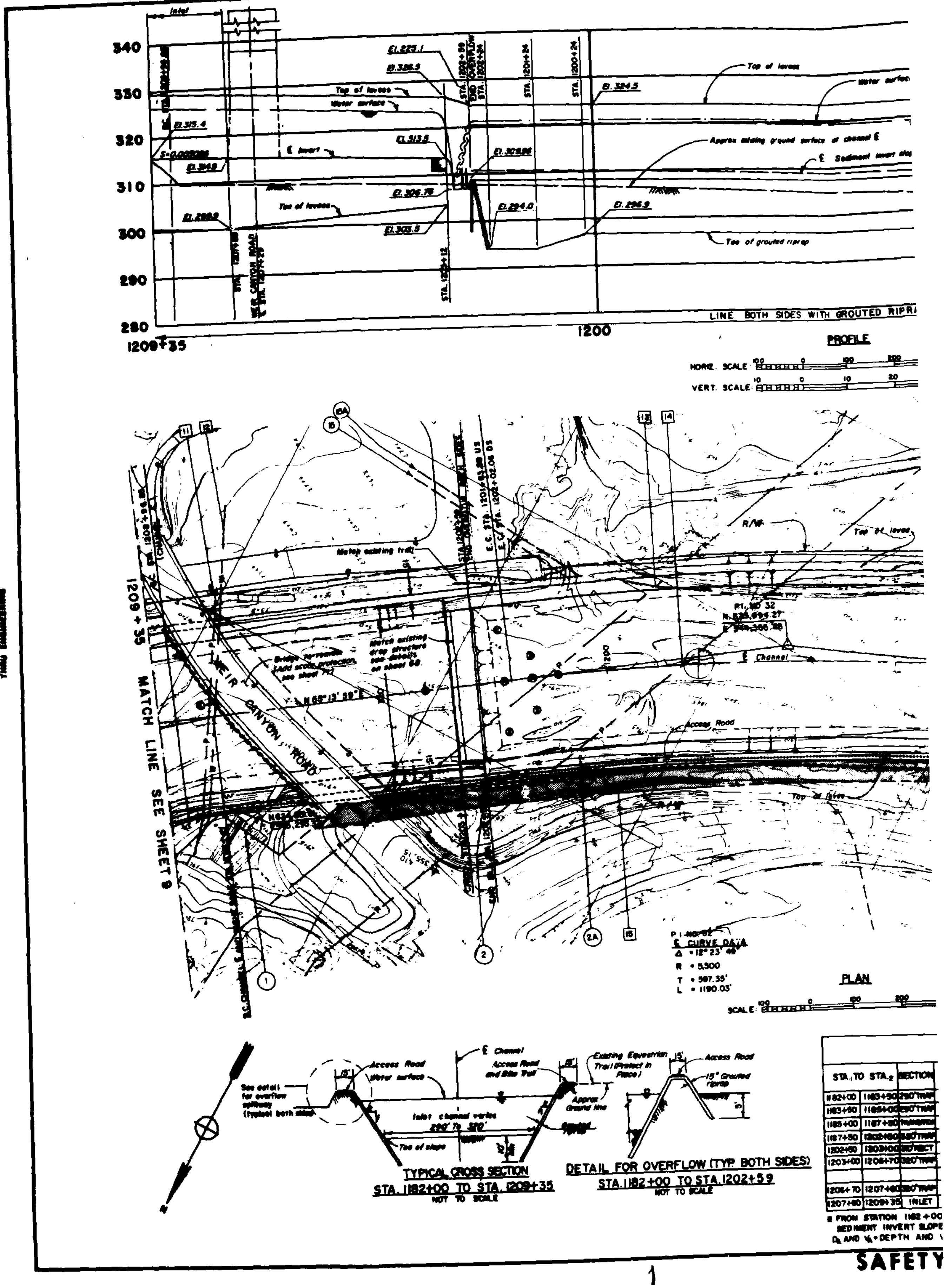
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 9 OF 105 SHEETS

PLATE 12

SAFETY PAYS

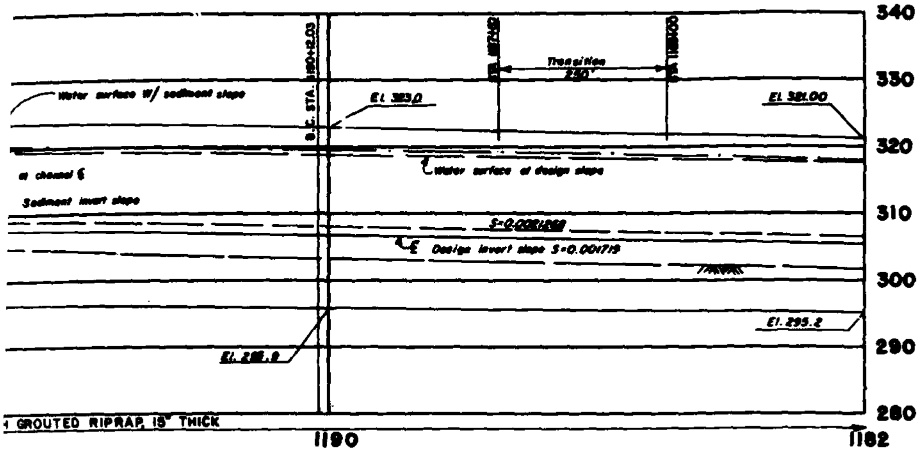
2

VALUE ENGIN

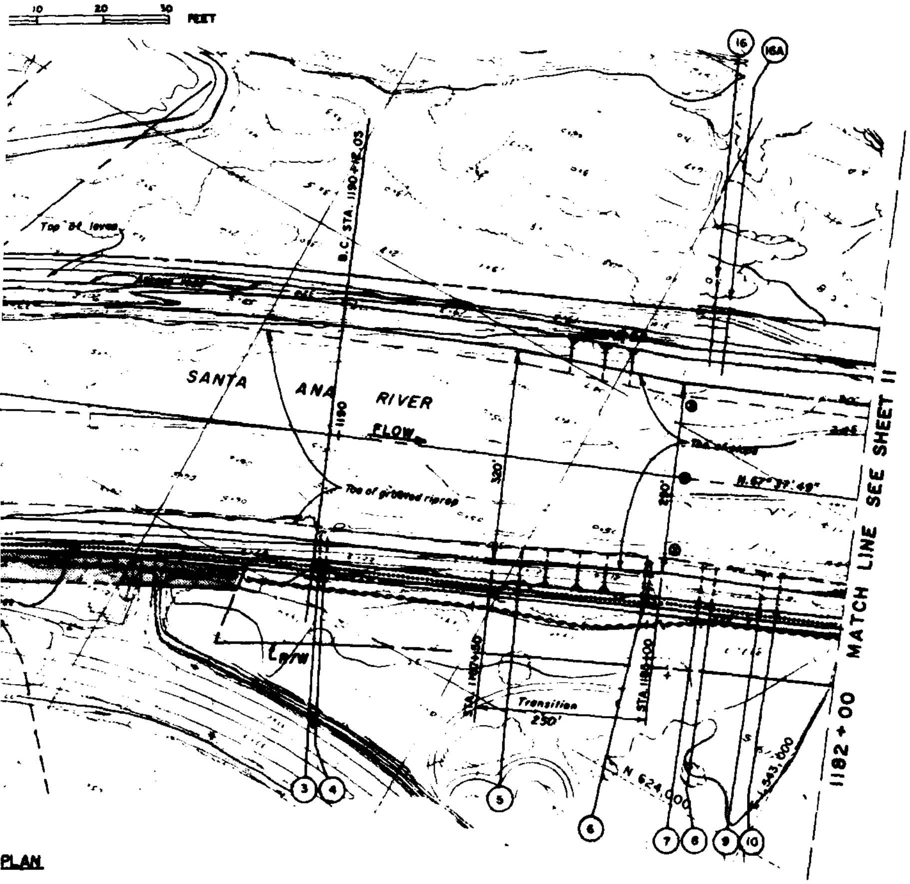


SAFETY

ENGINEERING PAYS



PROFILE



PLAN

100 200 300 FEET

NOTES:

1. REMOVE EXISTING SIDE SLOPE PROTECTION (18" FACING STONE W/ 6" FILTER)
2. PROVIDE OVERFLOW FOR BOTH LEVEES FROM STA. 1182+00 TO STA. 1202+59 SEE TYPICAL SECTION ON SHEET 9
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- ADDITIONAL R/W REQUIRED
- (NO.) UTILITY. SEE SHEET 62 FOR TABULATION.
- (NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- SCOUR GAGE – SEE DETAIL SHEET 9

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030			
							D_{a_1}	V_{a_1}	D_{a_2}	V_{a_2}
-00	1183+50	290' TRAP	0.001719	[illegible]	38,000	8.0	11.2	10.9	11.2	10.9
-50	1186+00	290' TRAP	0.001719	[illegible]	37,000	7.9	11.5	10.3	11.4	10.4
-00	1187+50	[illegible]	0.001719	[illegible]	37,000	VARIES	11.4	10.4	11.6	9.3
-50	1202+50	290' TRAP	0.001719	[illegible]	37,000	7.4	11.6	9.3	10.8	10.1
-50	1203+00	[illegible] RECT	DROP	STRUCTURE						
-00	1206+70	290' TRAP	.005026	–	37,000	7.4	10.1	10.8	9.7	11.3
							n = 0.040			
-70	1207+60	290' TRAP	.005026		37,000	7.4	9.7	11.3	10.1	10.8
-60	1209+35	INLET	.005026	–	37,000	VARIES	10.1	10.8	11.1	8.4

...M STATION 1182+00 TO 1202+50, DEPTHS AND VELOCITIES ARE BASED ON THE ...IMENT INVERT SLOPE.
...D V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: F. [illegible]
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1182+00 TO STA. 1209+35

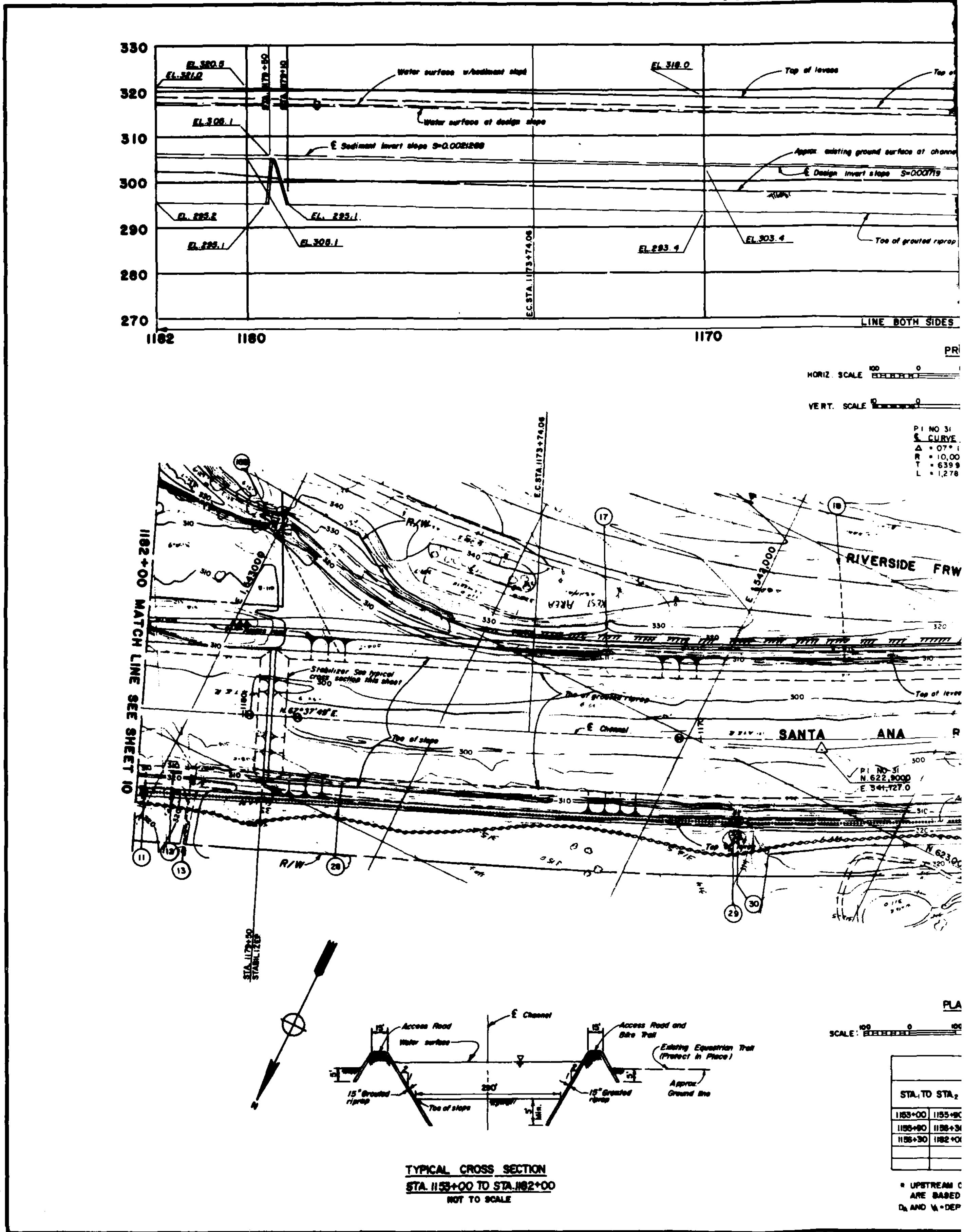
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 10 OF 108 SHEETS

PLATE 13

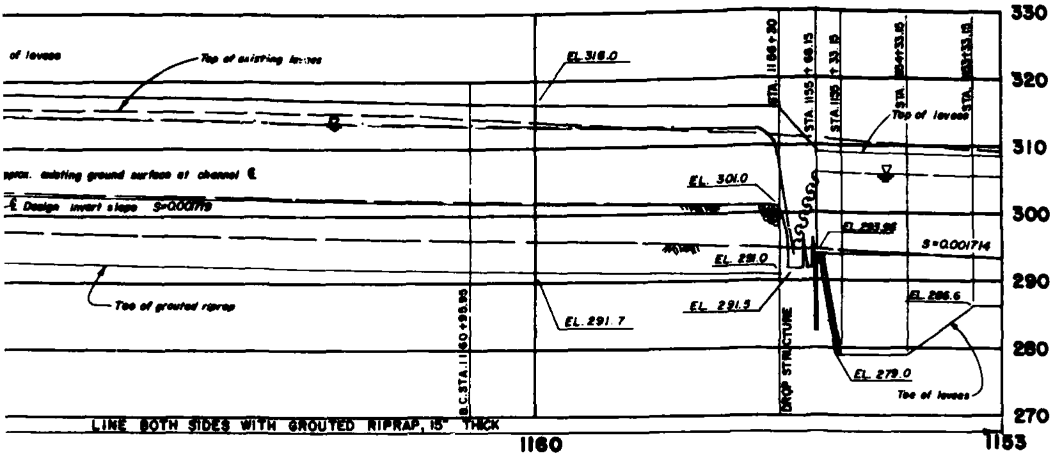
SAFETY PAYS

1

2



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

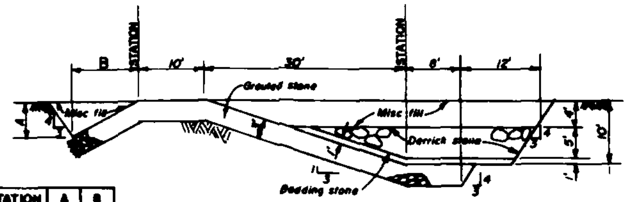


PROFILE

HORIZ. SCALE 100 0 100 200 300 FEET

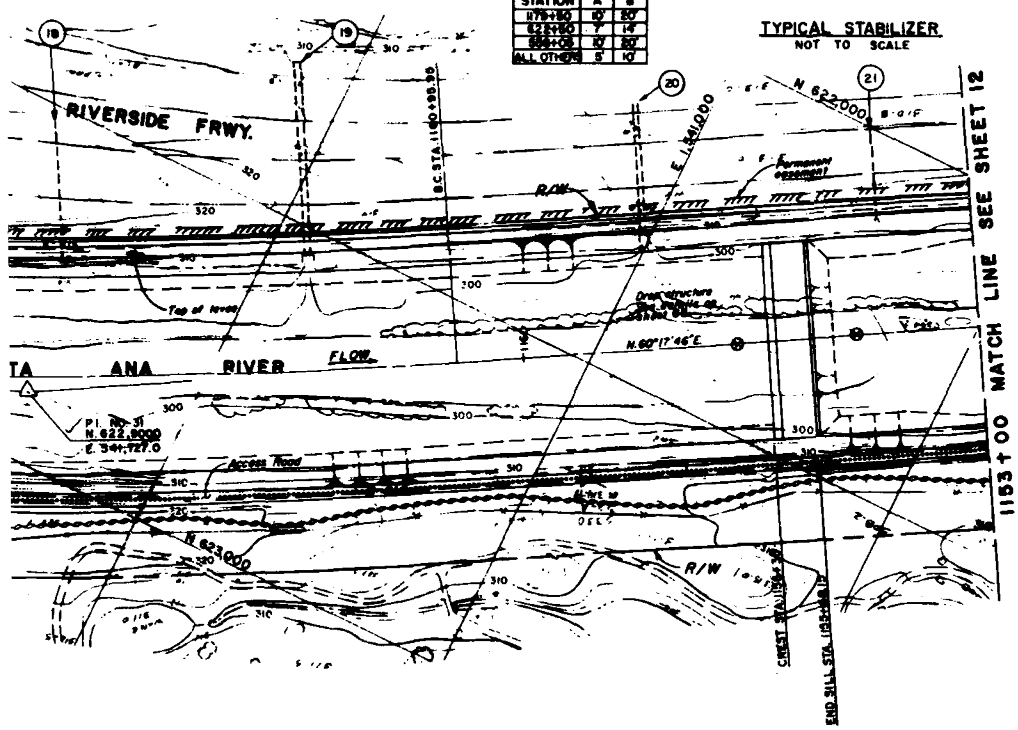
VERT. SCALE 10 0 10 20 30 FEET

P.I. NO. 31
℄ CURVE DATA
Δ = 07° 19' 23"
R = 10,000'
T = 639.93'
L = 1,278.11'



STATION	A	B
1179+50	10'	20'
622+50	7'	14'
656+05	10'	20'
ALL OTHERS	5'	10'

TYPICAL STABILIZER
NOT TO SCALE



NOTES:

1. REMOVE EXISTING SIDE SLOPE PROTECTION (18" TO 24" FACING STONE W/ 6" FILTER)
2. PROVIDE SIDE OVERFLOW FOR BOTH LEVEES SEE TYPICAL SHEET 9.
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

ADDITIONAL R/W REQUIRED

(NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS

EQUESTRIAN/HIKING TRAIL

NEW ACCESS ROAD AND BIKE TRAIL

⊗ SCOUR GAGE - SEE DETAIL SHEET 9

PLAN

SCALE: 100 0 100 200 300 FEET

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030*			
							D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
1153+00	1155+80	290' TRAP	0.001714	—	38,000	7.97	11.9	10.2	11.9	10.2
1155+80	1156+30	290' RECT	DROP STRUCTURE							
1156+30	1182+00	290' TRAP	0.001719	0.0021268	38,000	7.97	11.2	10.9	11.2	10.9

* UPSTREAM OF DROP STRUCTURE STATION 1156+30, DEPTHS AND VELOCITIES ARE BASED ON THE SEDIMENT INVERT SLOPE.

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:

DRAWN BY:

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1153+00 TO STA. 1182+00

SUBMITTED BY:

DATE APPROVED

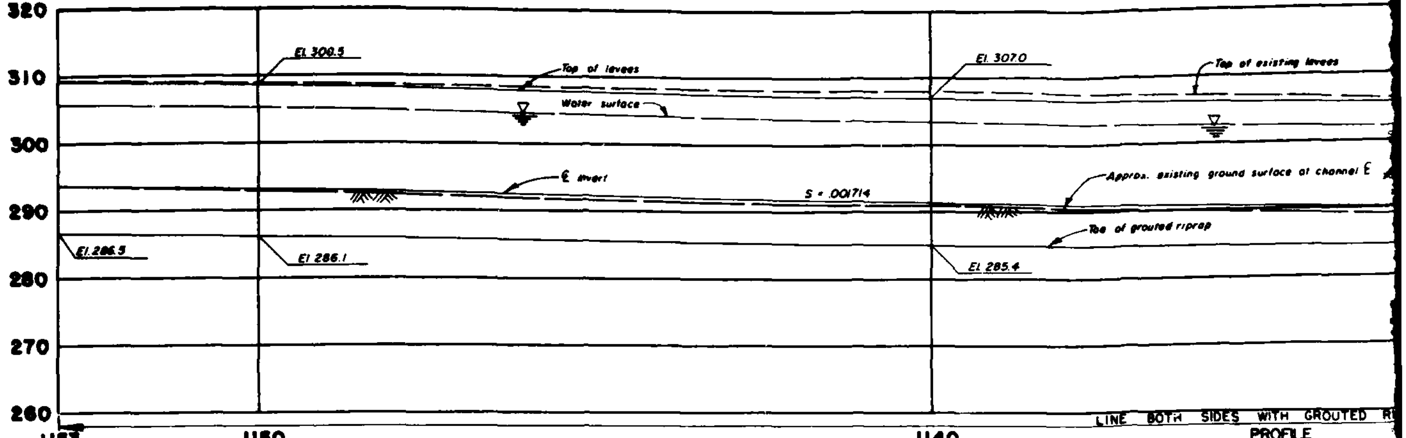
DISTRICT FILE NO.

SHEET 11 OF 108

PLATE 14

1

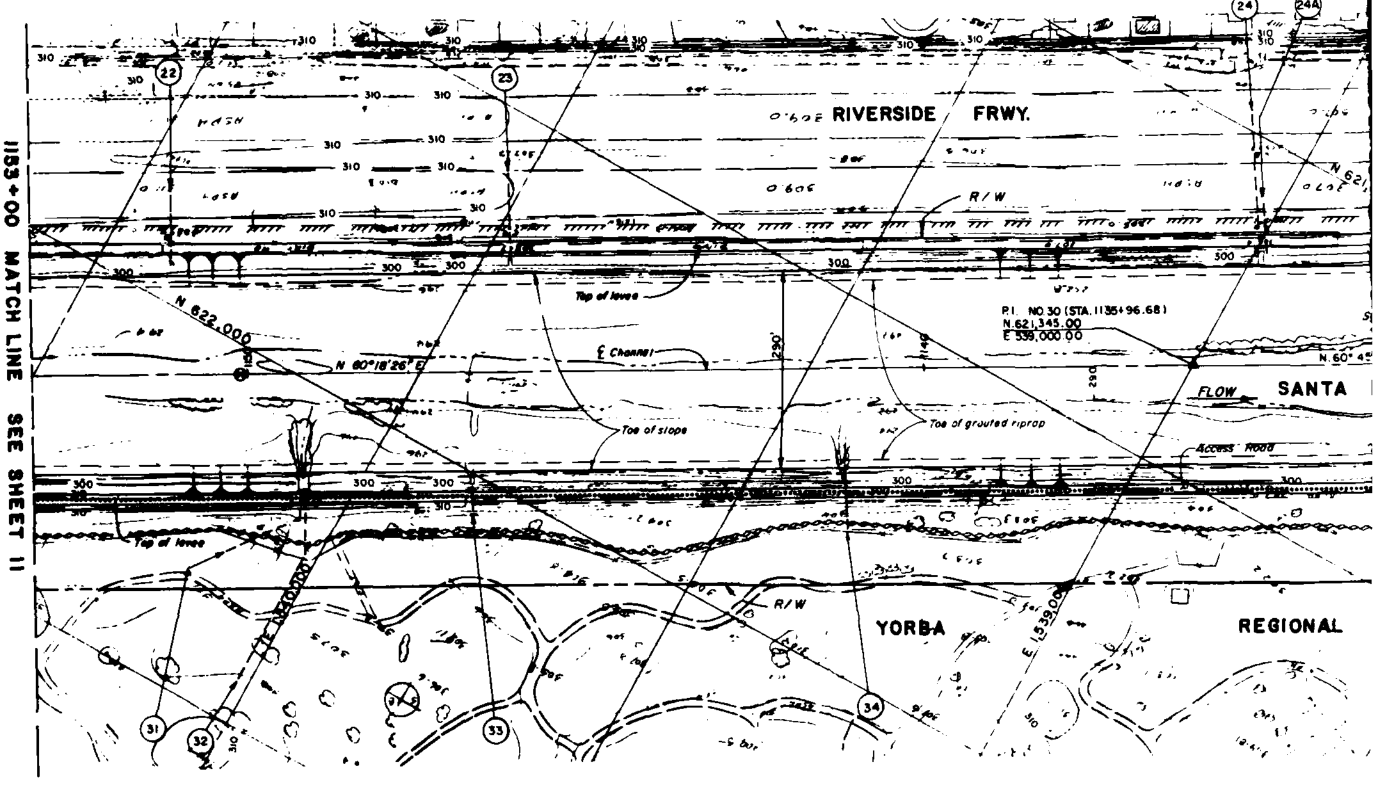
2



PROFILE

HORIZ. SCALE: 100 0 100 200

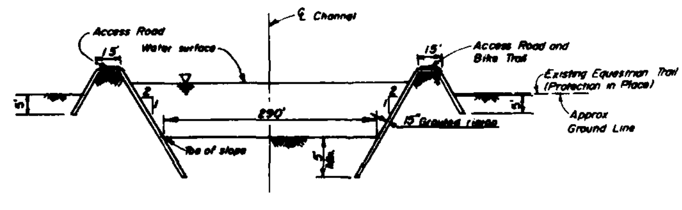
VERT. SCALE: 10 0 10 20



1153+00 MATCH LINE SEE SHEET 11

PLAN

SCALE: 100 0 100 200

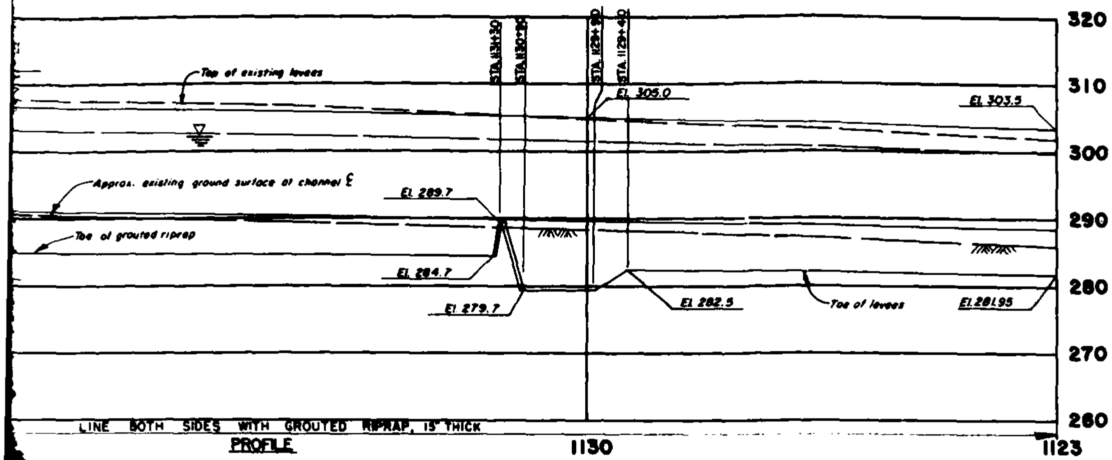


TYPICAL CROSS SECTION
STA. 1123+00 TO STA. 1153+00
NOT TO SCALE

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

STA
1123

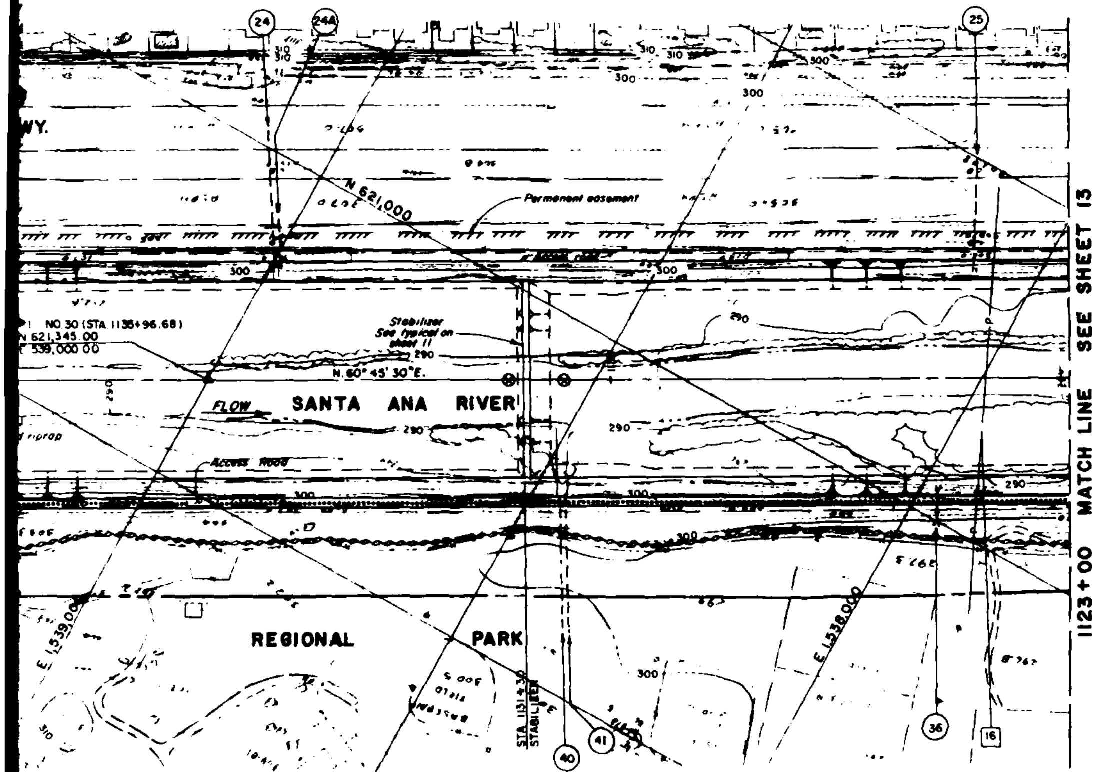
SAFETY PAYS



PROFILE

HORIZ. SCALE 100 0 100 200 300 FEET

VERT. SCALE 10 0 10 20 30 FEET



NOTE.

1. REMOVE EXISTING SIDE SLOPE PROTECTION (18" TO 24" FACING STONE W/6" FILTER
2. PROVIDE SIDE OVERFLOW FOR BOTH LEVEES. SEE TYPICAL ON SHEET 9.
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- NO. (square) UTILITY SEE SHEET 62 FOR TABULATION.
- NO. (circle) SIDE DRAIN SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN / HIKING TRAIL.
- NEW ACCESS RD. AND BIKE TRAIL.
- ⊗ SCOUR GAGE - SEE DETAIL SHEET 9

PLAN

SCALE: 100 0 100 200 300 FEET

HYDRAULIC ELEMENTS									
STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{a_1}	V_{a_1}	D_{a_2}	V_{a_2}
1123+00	1153+00	250'TRAP	0.001714	38,000	7.97	11.8	10.3	11.9	10.2

D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:

DRAWN BY: D. VILPPU

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1123+00 TO STA. 1153+00

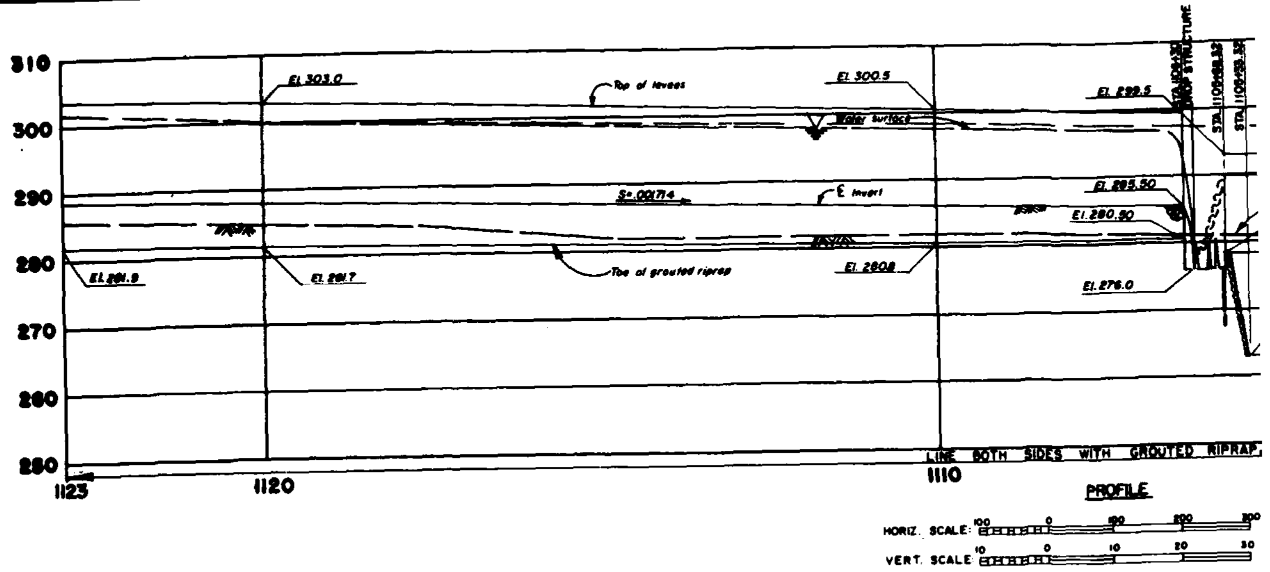
SUBMITTED BY:

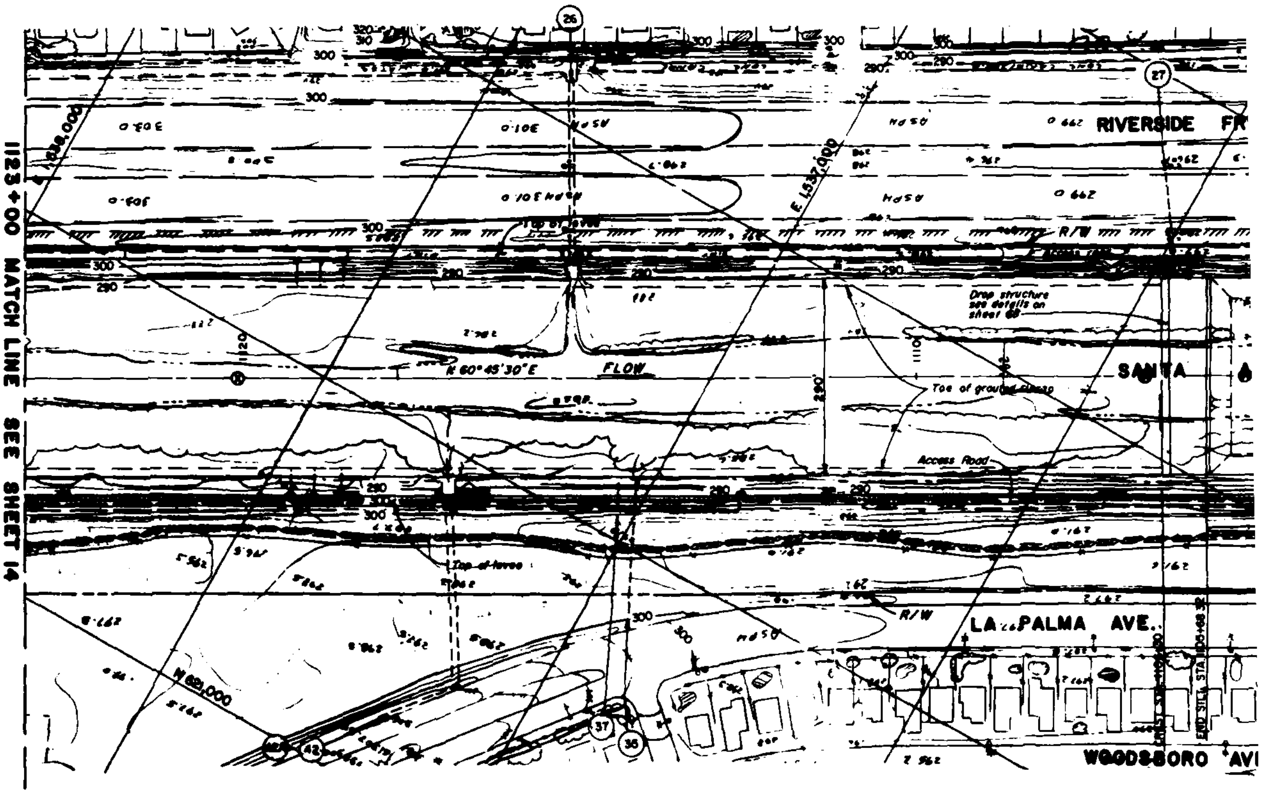
DATE APPROVED:

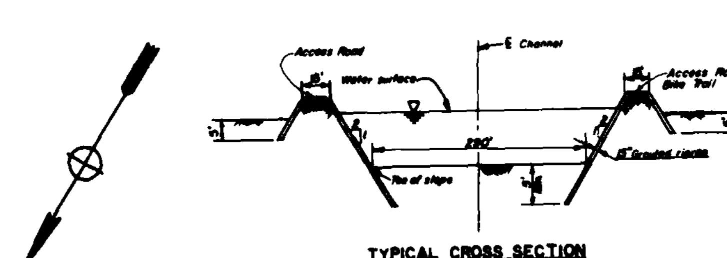
DISTRICT FILE NO.

SHEET 12 OF 105 SHEETS

PLATE

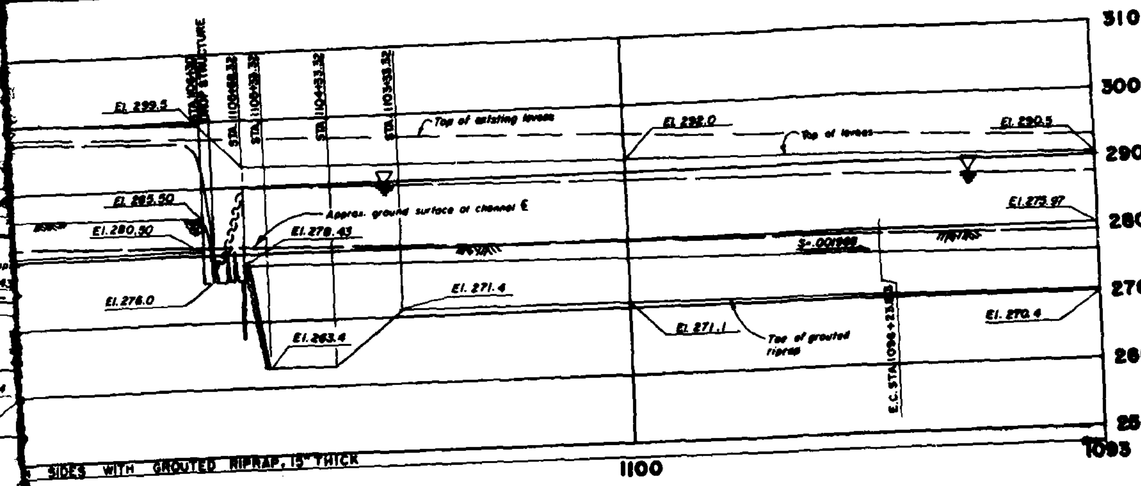




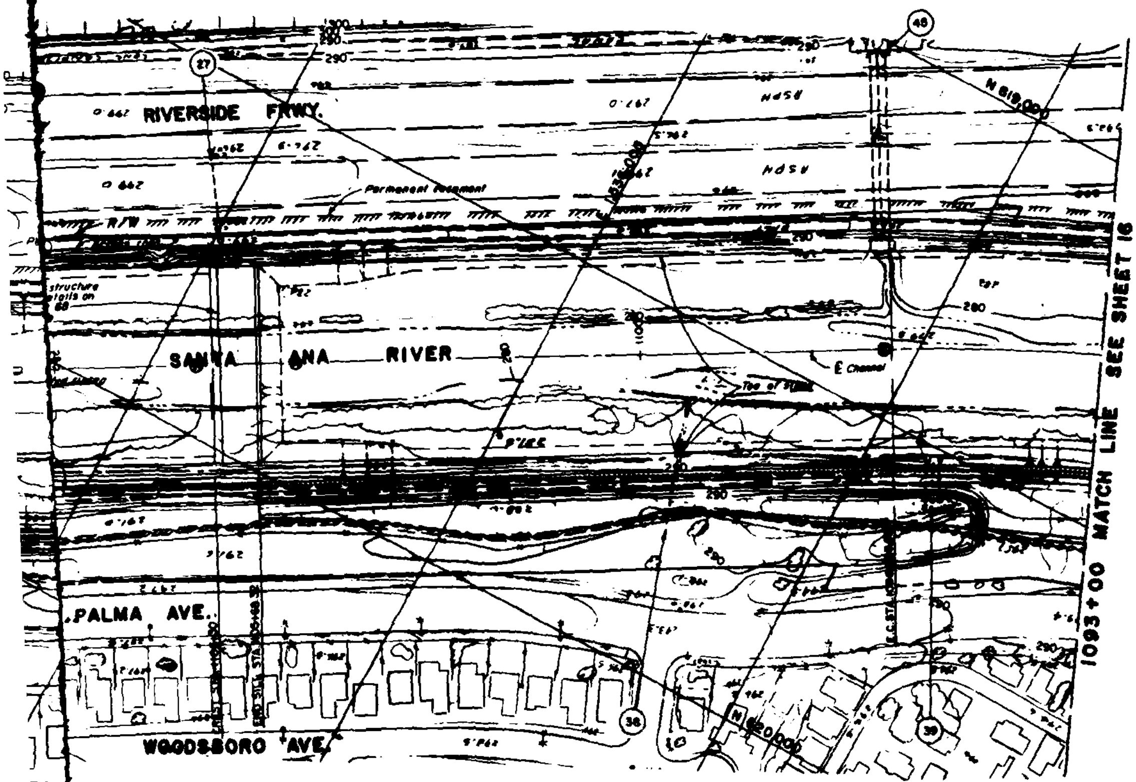


TYPICAL CROSS SECTION
STA.1093+00 TO STA.1123+00
NOT TO SCALE

VALUE ENGINEERING PAYS



PROFILE



PLAN

SCALE 100 0 100 200 300 FEET

NOTES:

1. REMOVE EXISTING SIDE SLOPE PROTECTION. (24" FACING STONE W/6" FILTER)
2. PROVIDE SIPE OVERFLOW FOR BOTH LEVEES SEE TYPICAL ON SHEET 9.
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

(NO.) SIDE DRAIN SEE SHEET 70 FOR DETAILS
EQUESTRIAN / HIKING TRAIL
NEW ACCESS ROAD AND BIKE TRAIL
SCOUR GAGES - SEE DETAIL SHEET 9

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{a_1}	V_{a_1}	D_{a_2}	V_{a_2}
1093+00	1108+50	380'TRAP	0.001946	38,000	7.97	11.6	10.5	11.6	10.6
1108+50	1108+80	380'TRAP/RECT DROP STRUCTURE							
1108+80	1123+00	380'TRAP	0.001714	38,000	7.97	11.2	10.9	11.8	10.3

D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

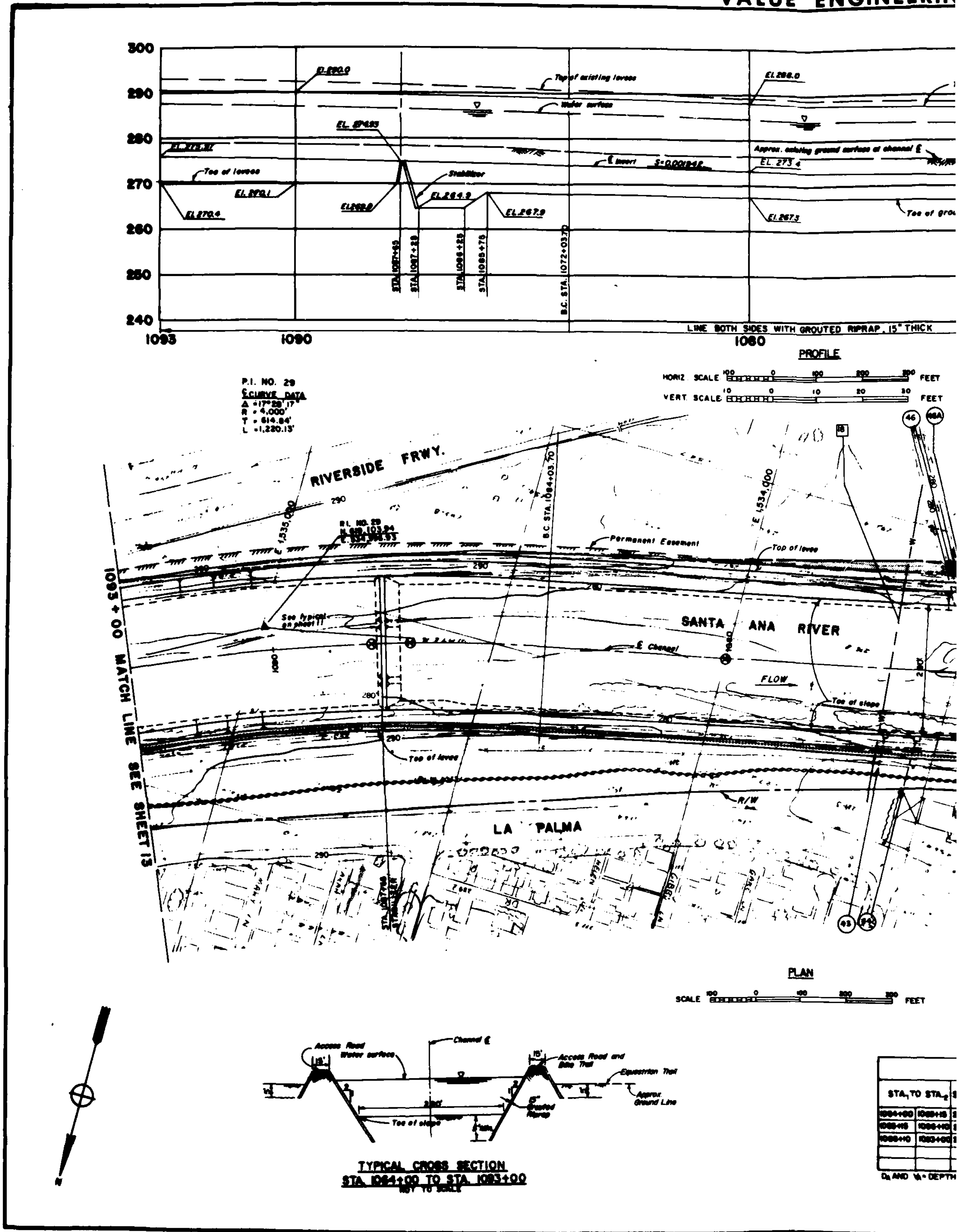
LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1093+00 TO STA. 1123+00

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 13 OF 105
PLATE 13

SAFETY PAYS

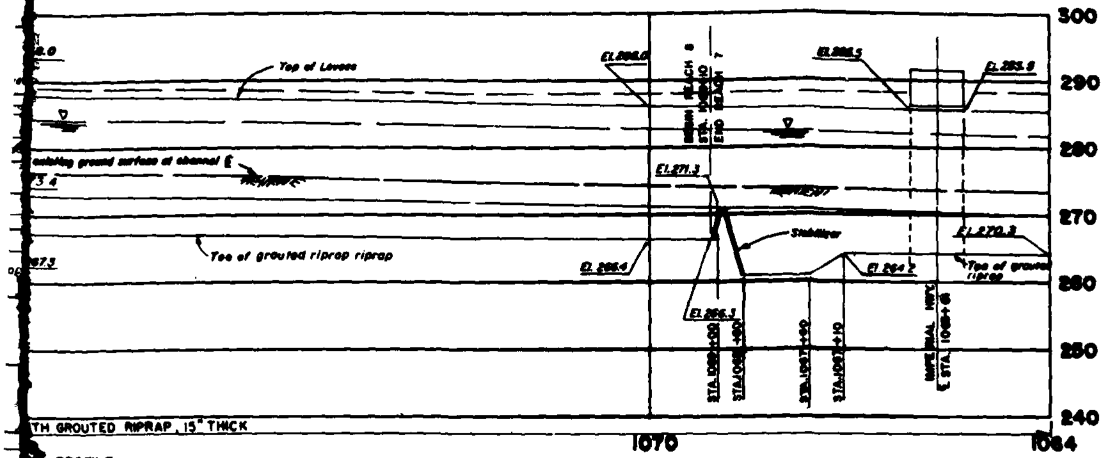
2

VALUE ENGINEERIN

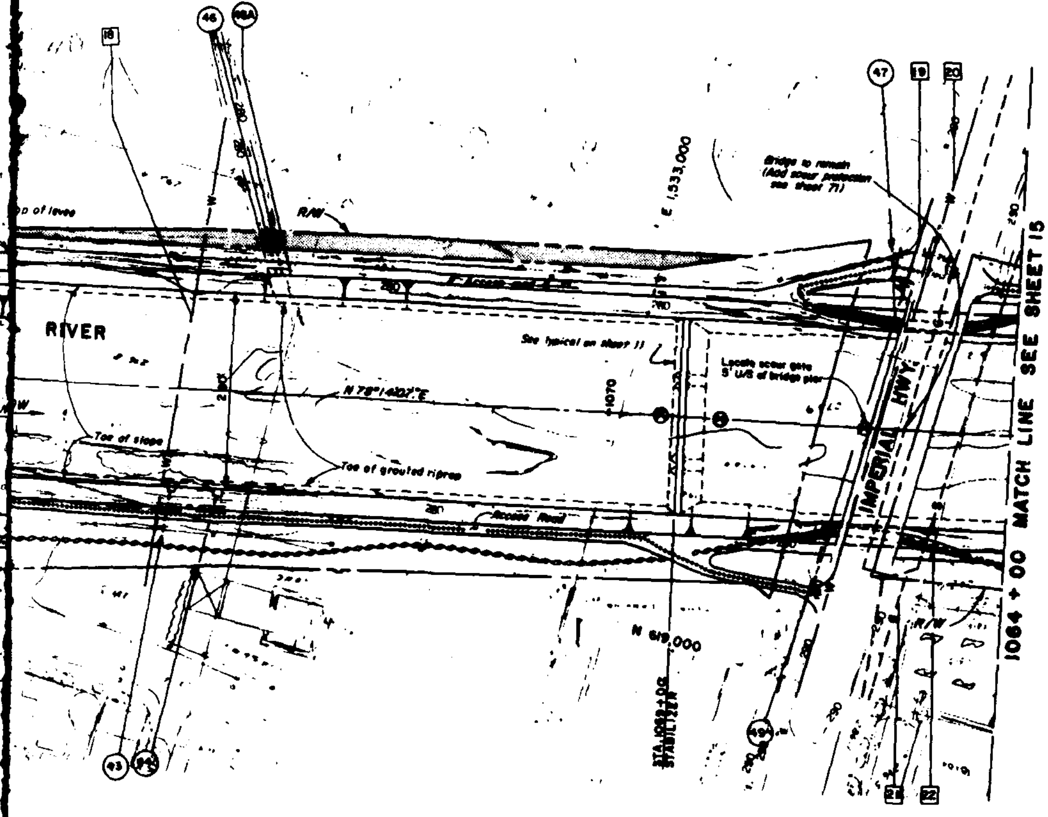


ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY PA



PROFILE



PLAN

NOTES:

1. REMOVE EXISTING SIDE SLOPE PROTECTION (24" FACING STONE WITH 6" FILTER.
2. PROVIDE SIDE OVERFLOW SEE TYPICAL ON SHEET 4.
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A C. PAVING DETAILS.

LEGEND

- ADDITIONAL R/W REQUIRED.
- UTILITY SEE SHEET 62 FOR TABULATION
- SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN / HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- SCOUR GAGE-SEE SHEET 9 FOR DETAIL.

HYDRAULIC ELEMENTS

STA_1 TO STA_2		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{a_1}	V_{a_1}	D_{a_2}	V_{a_2}
1064+00	[illegible]	290' TRAP	0.001842	38,000	7.97	11.4	10.7	11.4	10.7
[illegible]	[illegible]	290' TRAP	0.001842	38,000	7.97	11.4	10.7	11.7	10.4
[illegible]	[illegible]	290' TRAP	0.001842	38,000	7.97	11.7	10.4	11.6	10.5

D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1064+00 TO STA. 1093+00

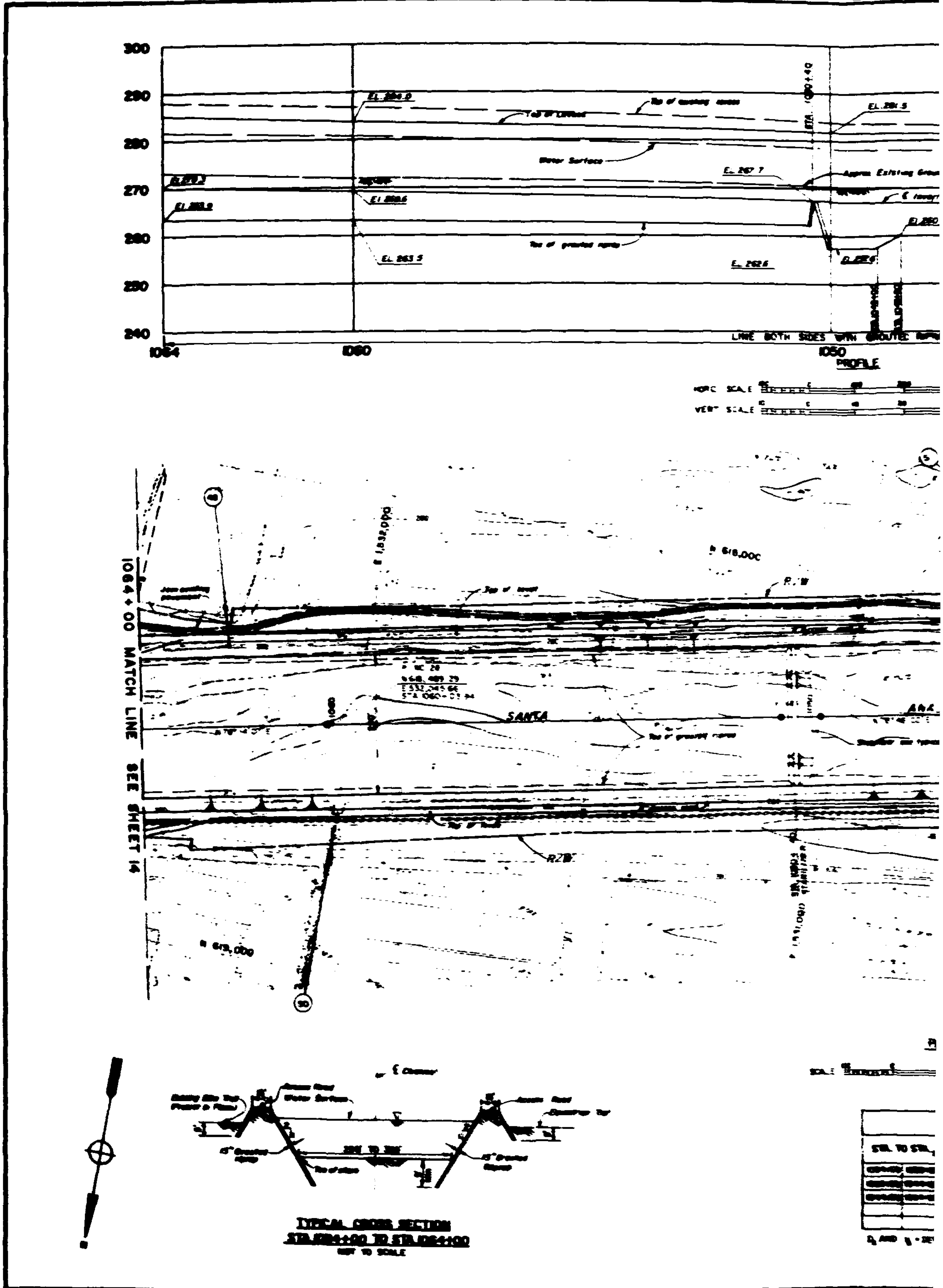
DESIGNED BY: DRAWN BY: CHECKED BY: SUBMITTED BY: DATE APPROVED: DISTRICT FILE NO.

SHEET 14 OF 108

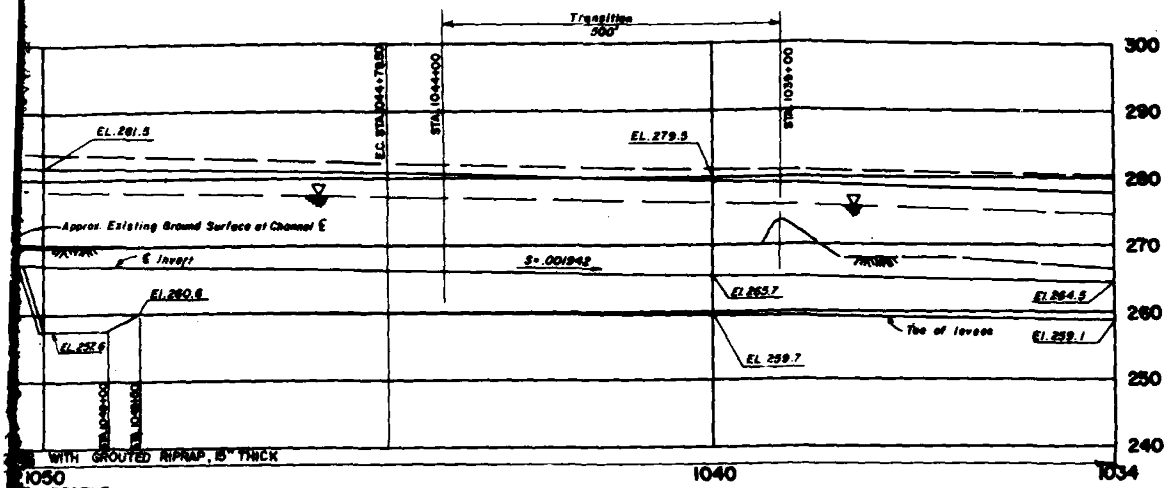
PLATE 17

2

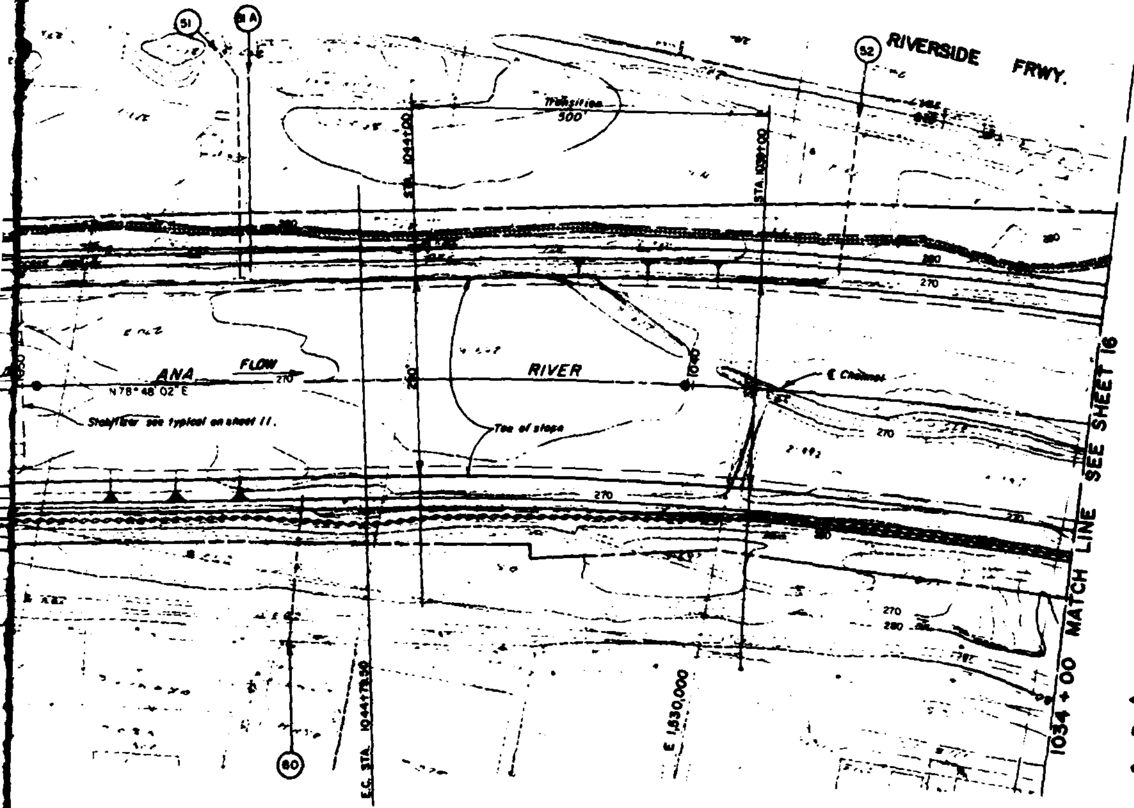
VALUE ENGINI



SAFETY



PROFILE



PLAN

SCALE 100 0 100 200 300 FEET

NOTE:
1. REMOVE EXISTING SIDE SLOPE PROTECTION. (24" FACING STONE WITH 6" FILTER)
2. PROVIDE SIDE OVERFLOW FOR BOTH LEVEES. SEE TYPICAL SHEET 9.
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

(NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS
EQUESTRIAN/HIKING TRAIL
NEW BIKE TRAIL
EXISTING BIKE TRAIL-PROTECT IN PLACE
⊗ SCOUR GAGE-SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
1034+00	1039+00	280' TRAP	0.001942	38,000	7.48	10.4	10.7	10.6	10.5
1039+00	1044+00	TRANSITION	0.001942	38,000	VARIES	10.6	10.5	10.6	11.6
1044+00	1064+00	280' TRAP	0.001942	38,000	7.97	10.6	11.6	11.4	10.7

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:
DRAWN BY: YBA
CHECKED BY:

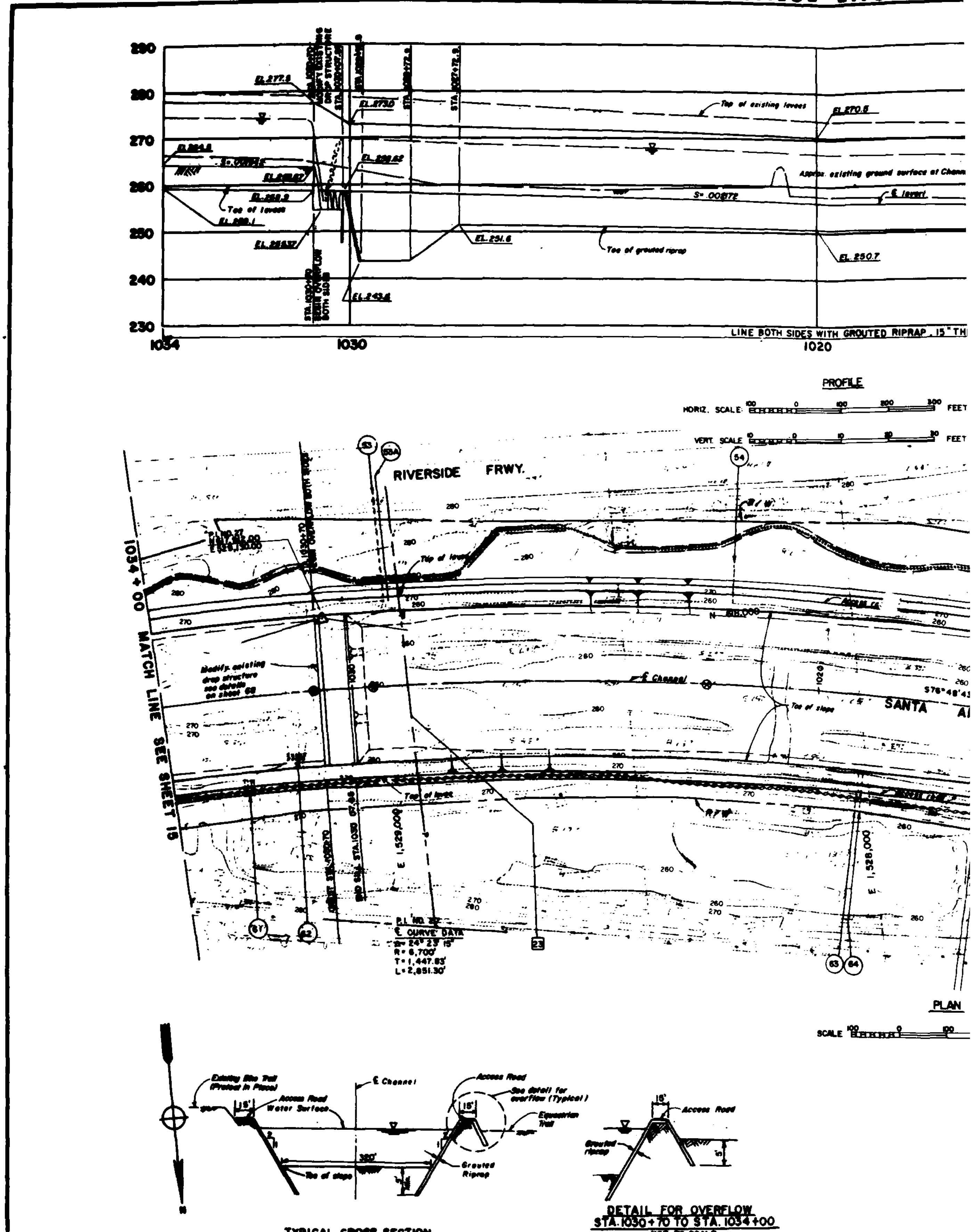
LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1034+00 TO STA. 1064+00

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 15 OF 105
PLATE 15

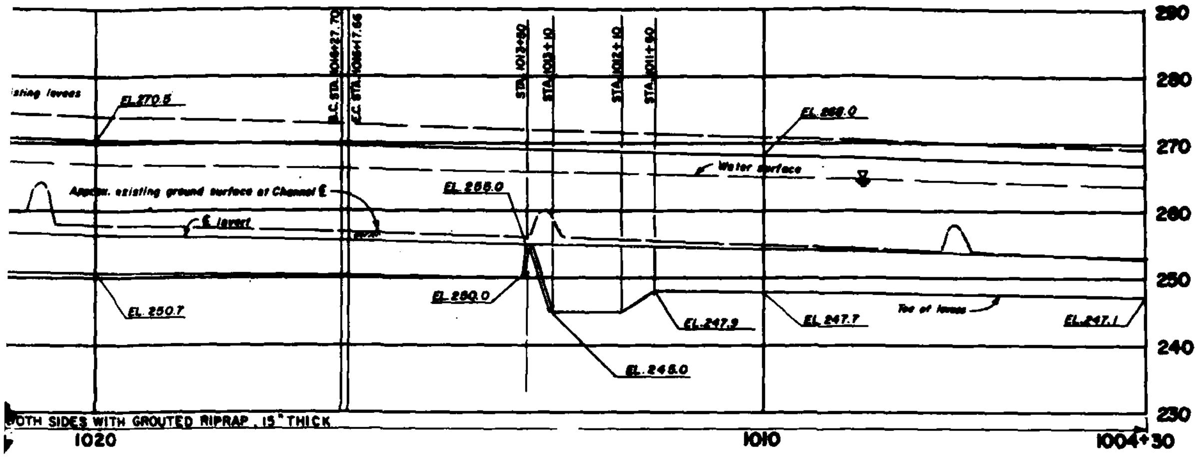
1

2

VALUE ENGINEERI



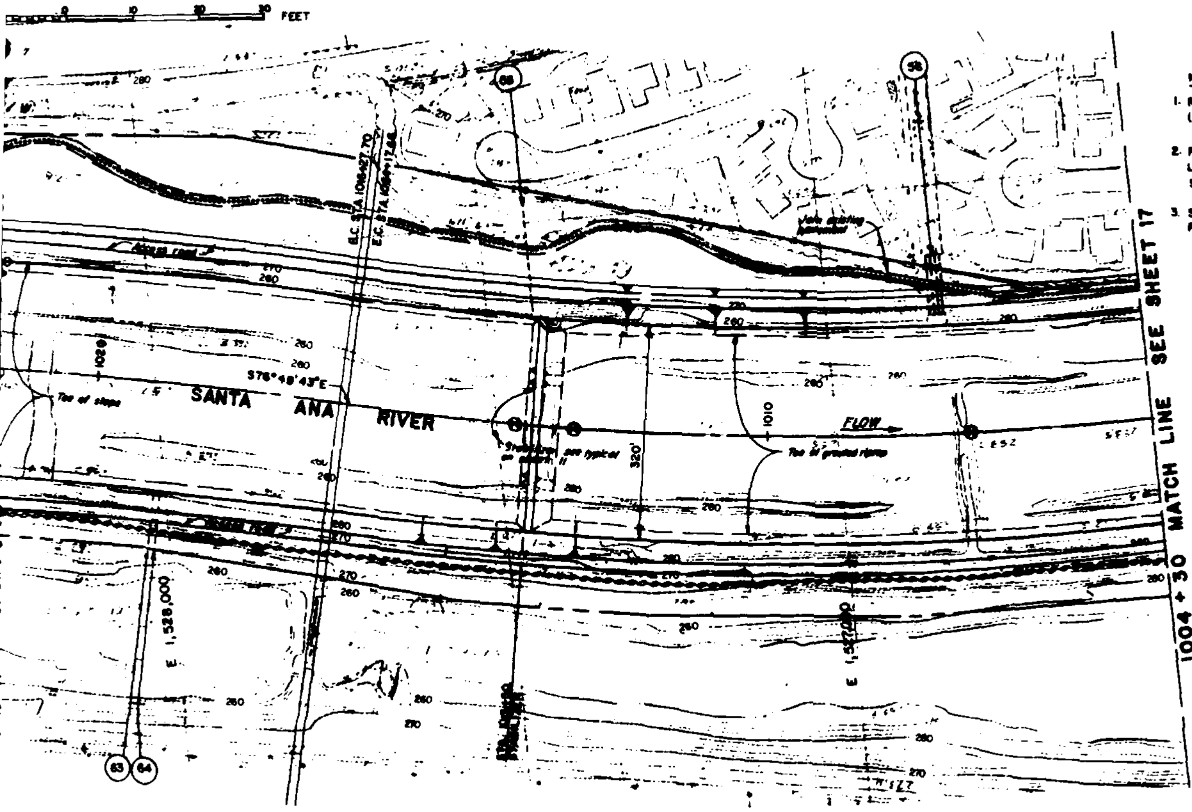
SAFETY PA



PROFILE

SCALE 100 0 100 200 300 FEET

SCALE 10 0 10 20 30 FEET



PLAN

SCALE 100 0 100 200 300 FEET

NOTES:

1. REMOVE EXISTING SIDE SLOPE PROTECTION (24" FACING STONE W/ 18" FILTER)
2. PROVIDE SIDE OVERFLOW FOR BOTH LEVEES BEGINNING AT STA. 1030+70. SEE TYPICAL SECTION ON SHEET 9
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- NO. UTILITY. SEE SHEET 62 FOR TABULATION
- (NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- ⊗ SCOUR GAGE - SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA.$_1$ TO STA.$_2$		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{a_1}	V_{a_1}	D_{a_2}	V_{a_2}
1004+30	1030+01.48	380' TRAP	0.002172	38,000	7.48	10.6	10.5	10.6	10.8
1030+01.48	1031+70	310' RECT	DROP STRUCTURE						
1031+70	1034+00	380' TRAP	0.001942	38,000	7.48	10.3	10.9	10.4	10.7

D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: GBA BRY

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 1004+30 TO STA. 1034+00

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

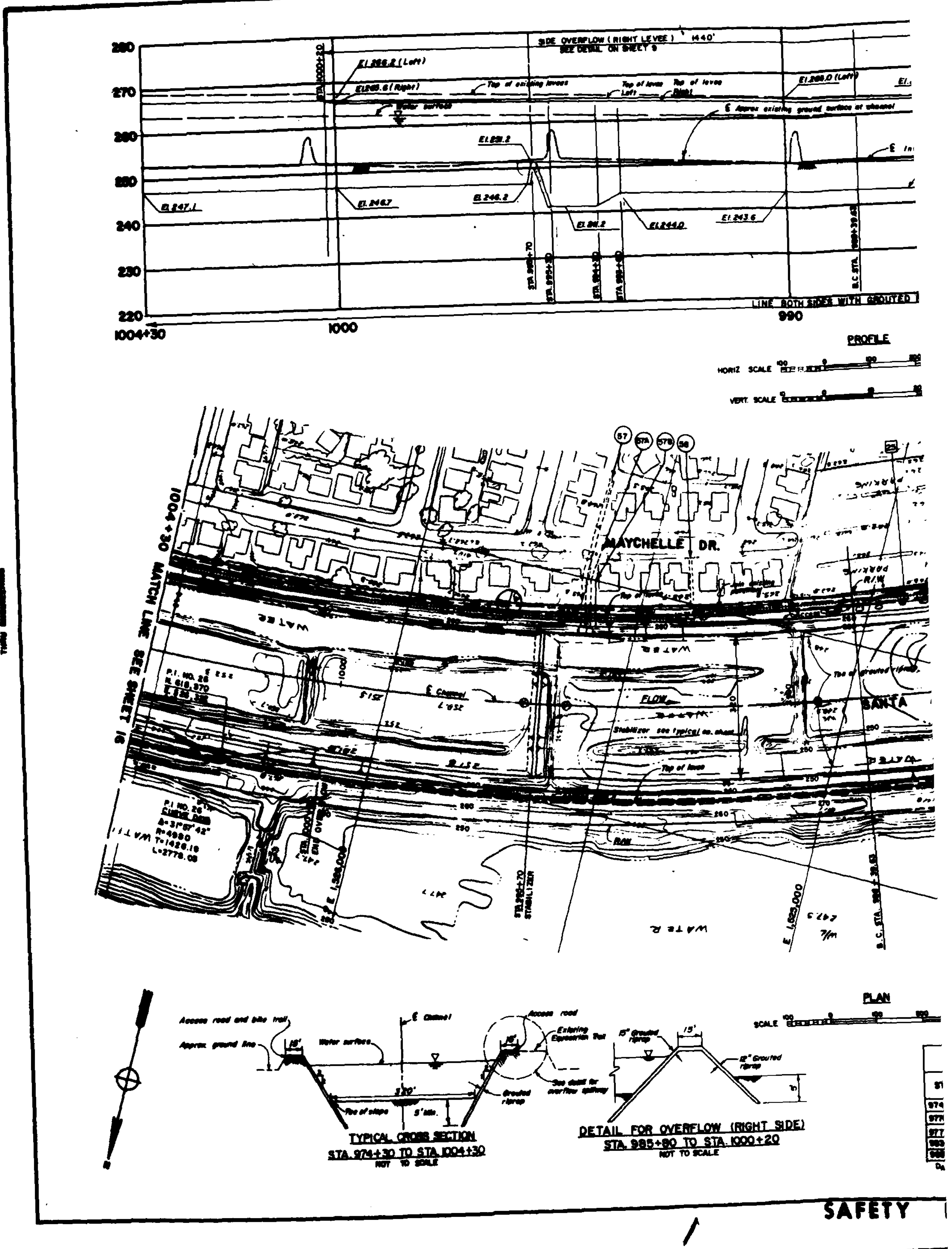
SHEET 16 OF 106

PLATE 16

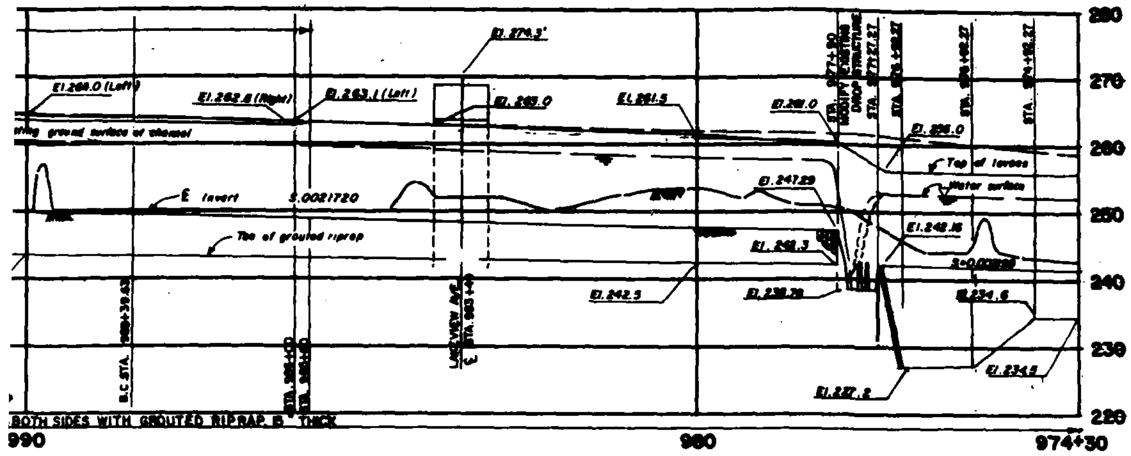
1

2

VALUE ENGINEEI



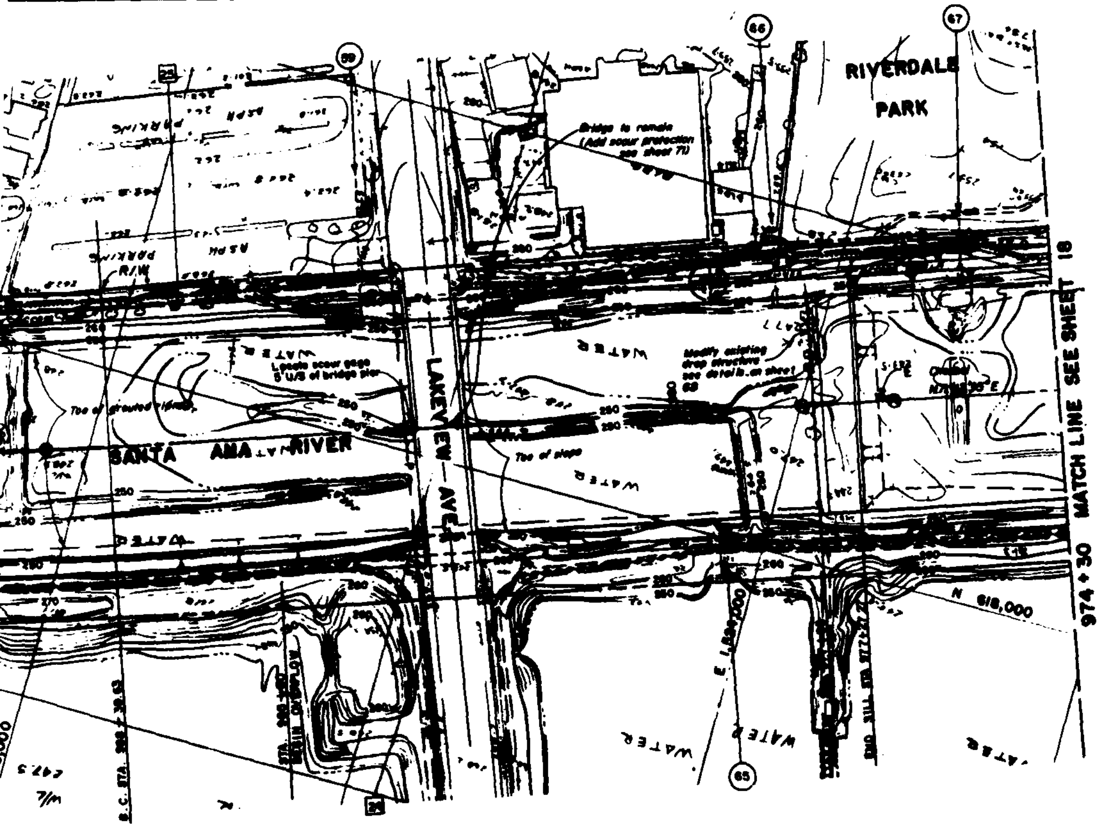
SAFETY



PROFILE

FEET

FEET



PLAN

FEET

NOTES:

1. REMOVE EXISTING SIDE SLOPE PROTECTION (24" FACING STONE W/18" FILTER). STONE D/S OF LAKEVIEW AVENUE MAY BE SALVAGED FOR REUSE.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- NO. UTILITY, SEE SHEET 62 FOR TABULATION
- (NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS RD. AND BIKE TRAIL
- EXISTING BIKE TRAIL - PROTECT IN PLACE
- SCOUR GAGE - SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA_1 TO STA_2		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						DA_1	VA_1	DA_2	VA_2
974+30	977+82.40	[illegible]	0.00[illegible]	38,000	7.48	10.6	10.6	10.6	10.6
977+82.40	977+90	[illegible]	[illegible]						
977+90	983+10	[illegible]	0.002172	38,000	7.48	10.3	10.9	10.4	10.7
983+10	[illegible]	[illegible]	0.002172	38,000	7.48	10.4	10.7	10.8	10.2
[illegible]	[illegible]	[illegible]	0.002172	38,000	7.48	10.9	10.3	10.8	10.3

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929.

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

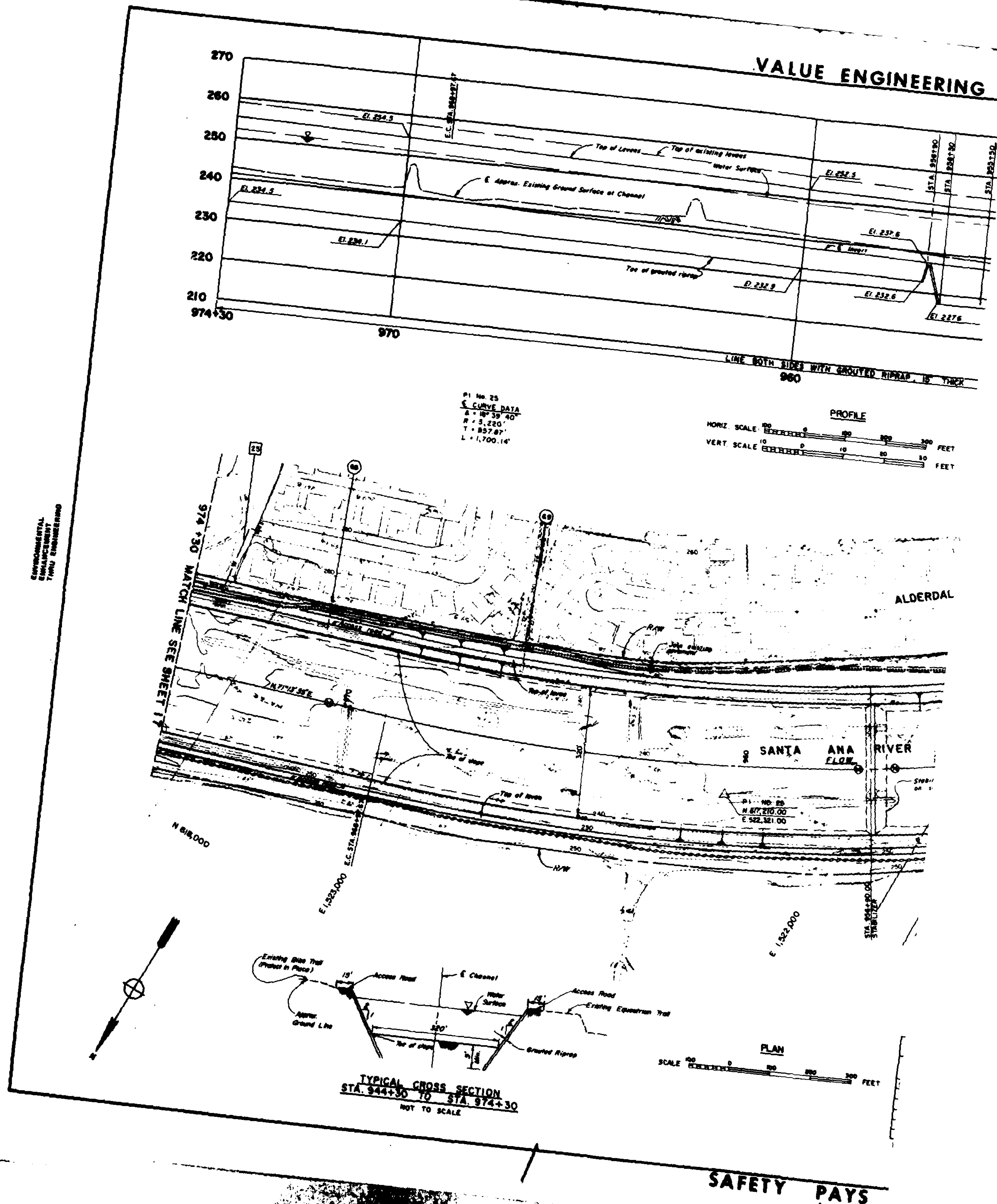
LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 974+30 TO STA. 1004+30

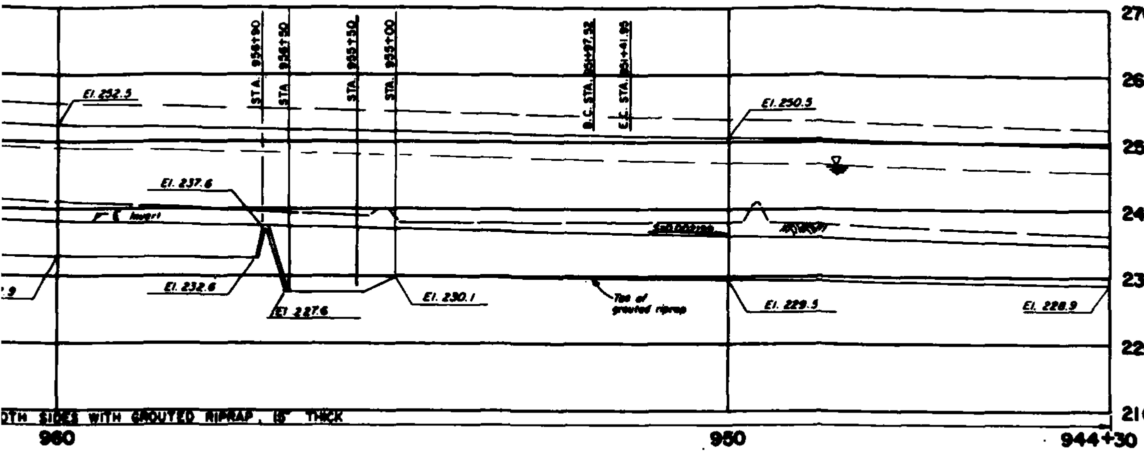
DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

SHEET 17 OF 106

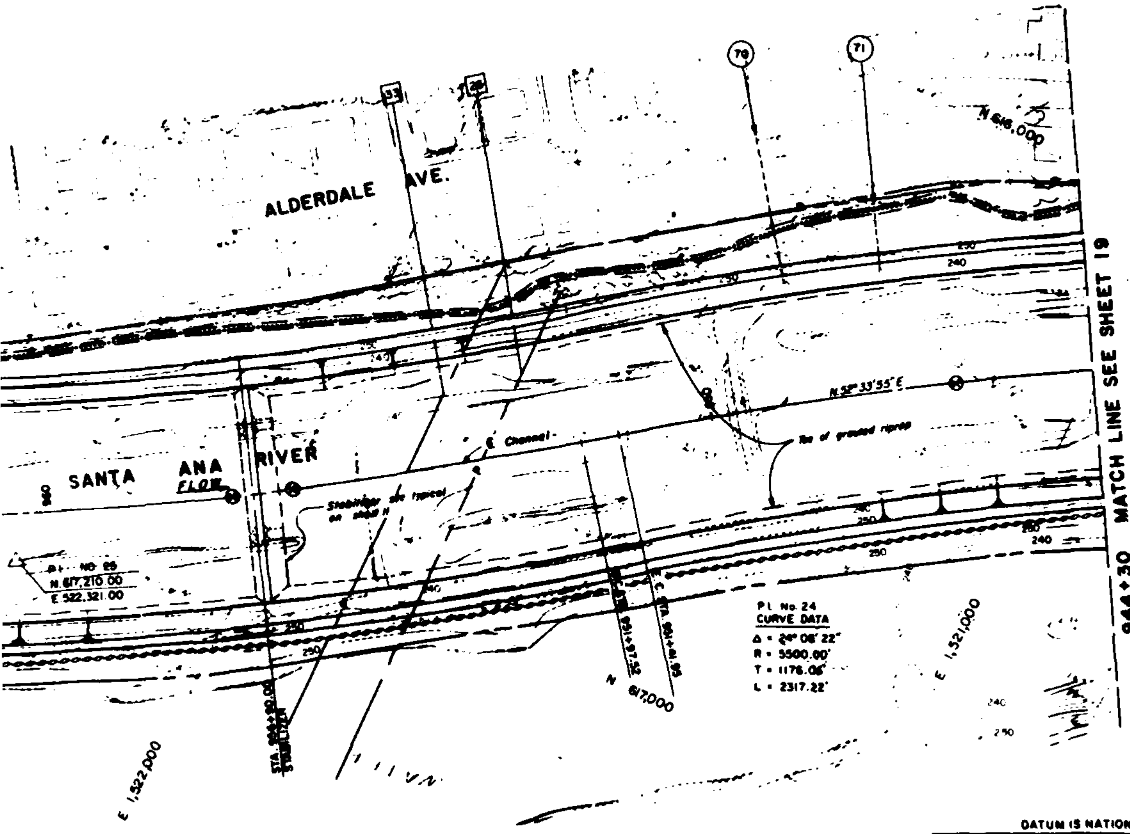
PLATE

2


VALUE ENGINEERING
270
260
250
240
230
220
210
974+30
970
960
El. 254.5
El. 234.5
El. 236.1
El. 252.5
El. 237.6
El. 232.9
El. 232.6
Top of Levees
Top of existing levees
Water Surface
Top of grouted riprap
LINE BOTH SIDES WITH GROUTED RIPRAP, 15" THICK
PI No. 25
CURVE DATA
Δ = 18° 39' 40"
R = 5,220'
T = 857.67'
L = 1,700.14'
PROFILE
HORIZ. SCALE
VERT. SCALE
FEET
974+30 MATCH LINE SEE SHEET 17
ALDERDAL
SANTA ANA RIVER
FLOW
Top of slope
Top of levee
N 618,000
E 1,523,000
E 1,522,000
PI No. 25
N 617,210.00
E 522,321.00
Existing Bike Trail (Protect in Place)
Access Road
Channel
Water Surface
Approx. Ground Line
Top of slope
320'
Existing Equestrian Trail
Grouted Riprap
PLAN
SCALE
TYPICAL CROSS SECTION
STA. 944+30 TO STA. 974+30
NOT TO SCALE
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING
SAFETY PAYS



PROFILE



NOTE:

1. REMOVE EXISTING SIDE SLOPE PROTECTION (18" FACING STONE W/ 6" FILTER) SALVAGE STONE FOR REUSE
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- NO — UTILITY SEE SHEET 62 FOR TABULATION
- (NO) — SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- ⊗ — SCOUR GAGE-SEE SHEET 9 FOR DETAIL

PLAN

HYDRAULIC ELEMENTS

STA. TO STA.		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{a_1}	V_{a_1}	D_{a_1}	V_{a_1}
944+30	974+30	380' TRAP	0.002199	38,000	7.48	10.9	10.2	10.6	10.6

D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

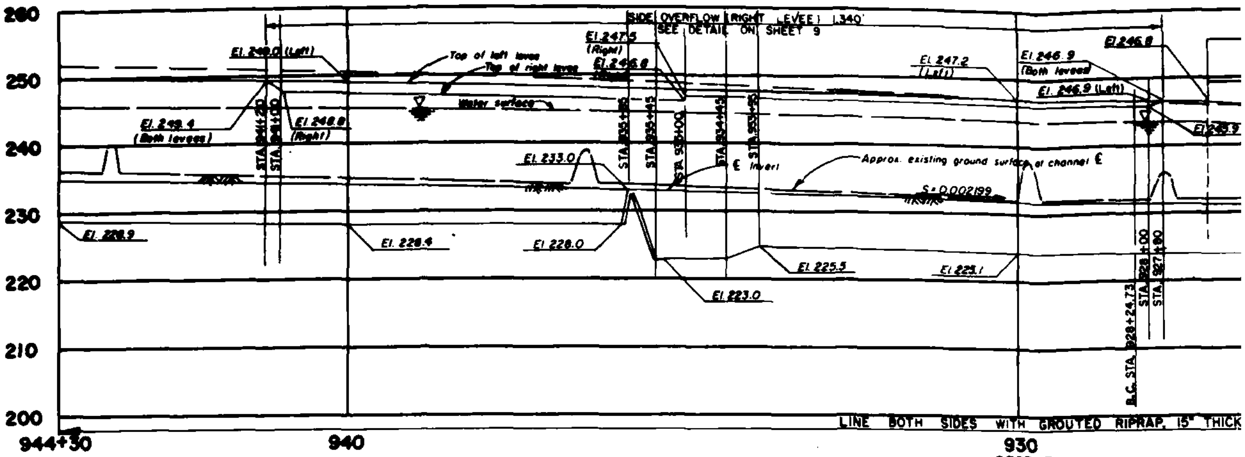
REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

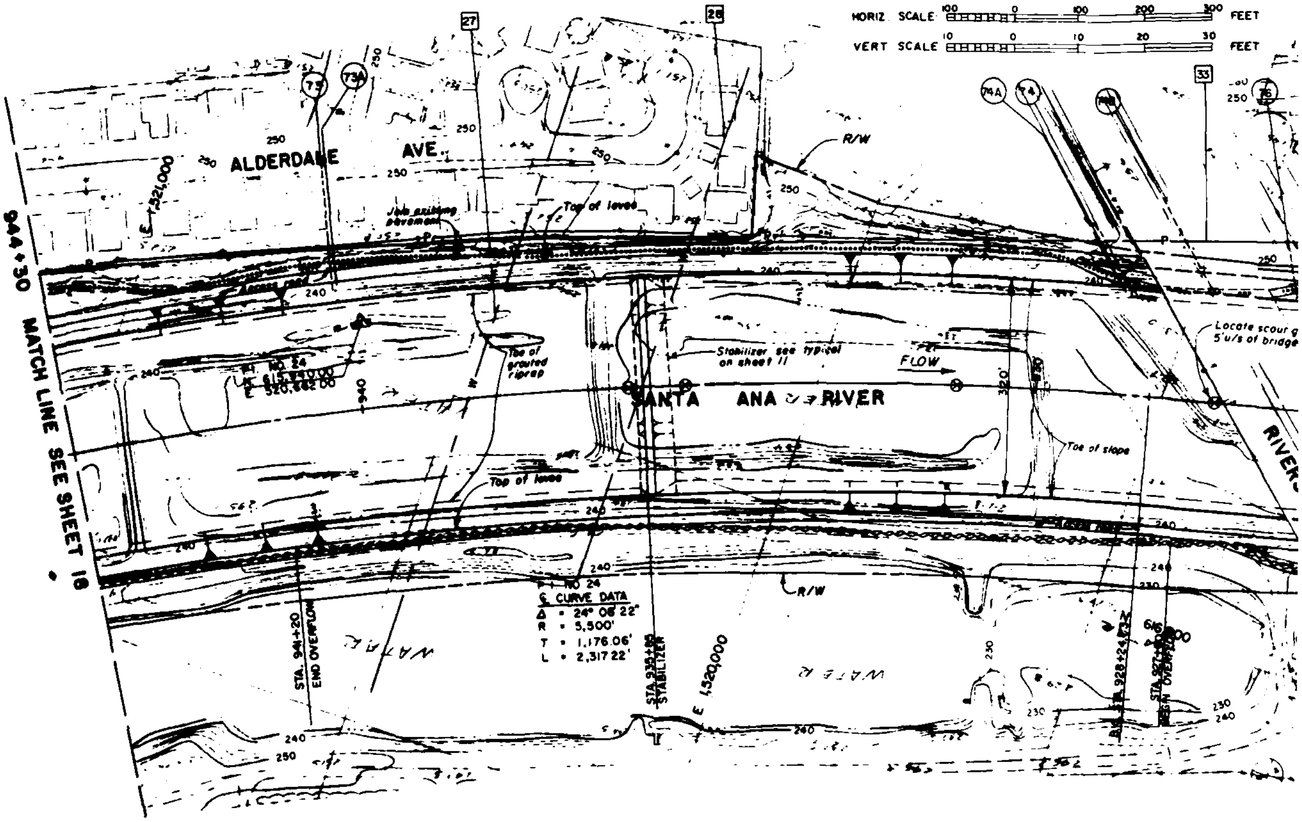
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 944+30 TO STA. 974+30

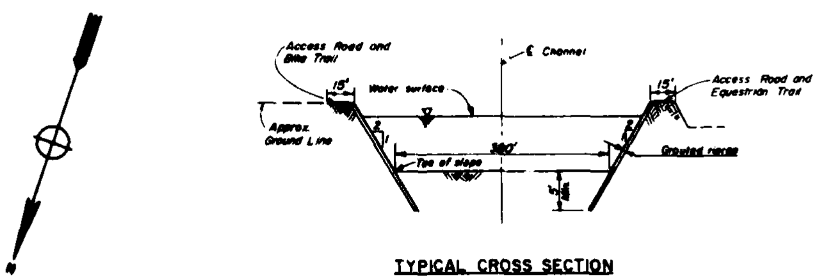
DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 18 OF 105



PROFILE

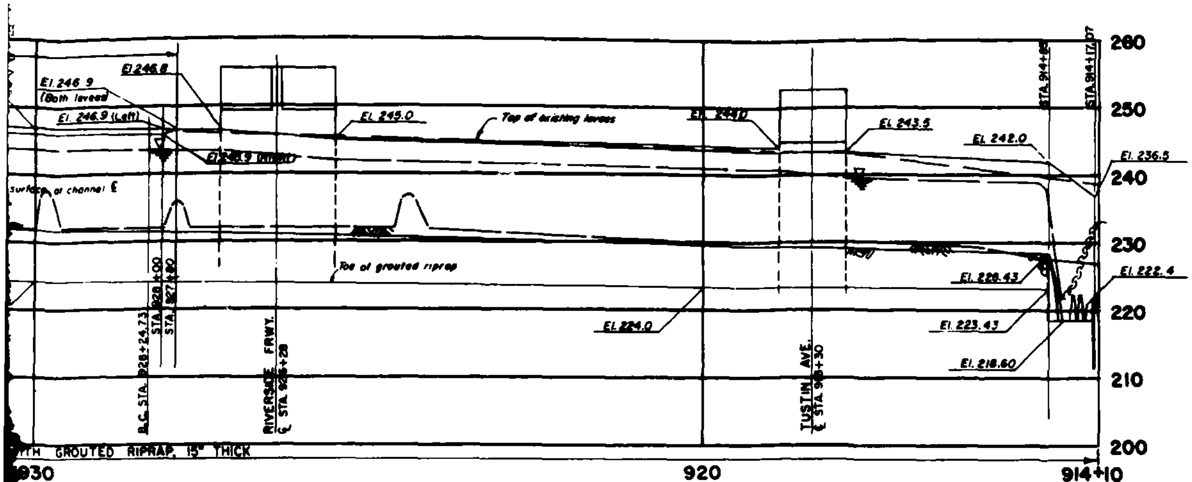


PLAN

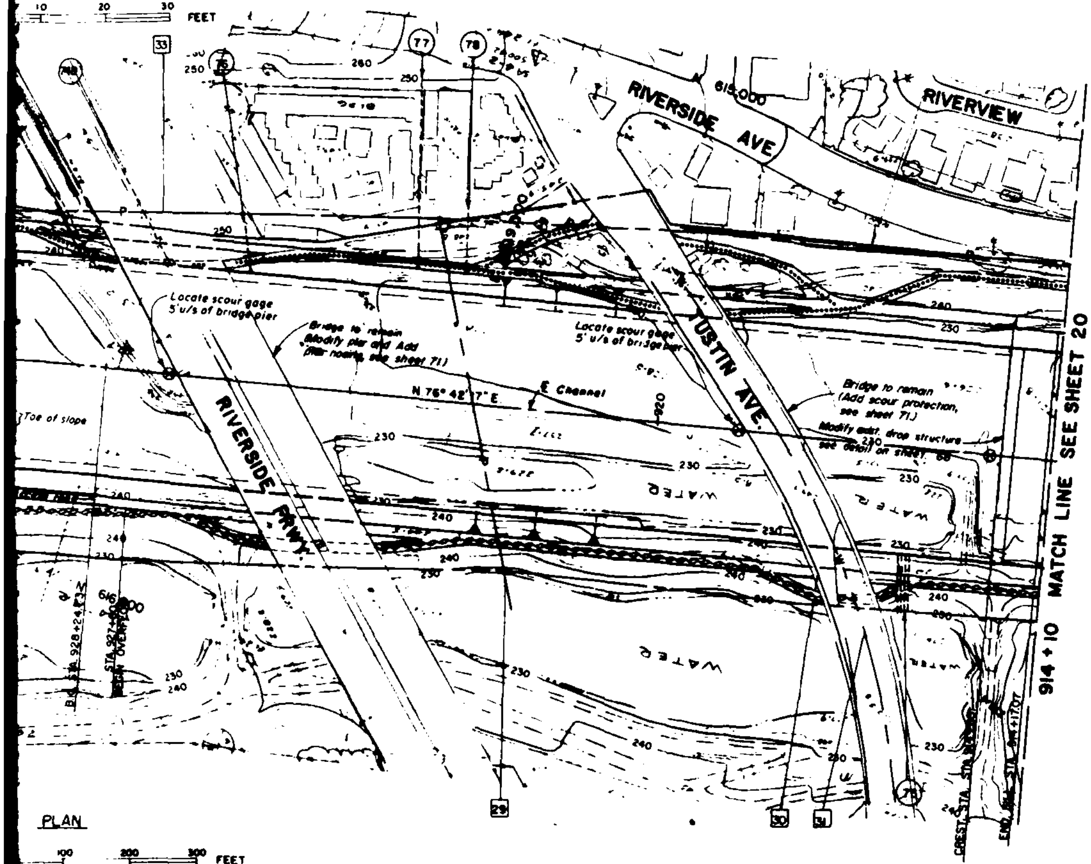


TYPICAL CROSS SECTION
STA. 914+10 TO STA. 944+30
NOT TO SCALE

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



PROFILE



PLAN

NOTE:

1. REMOVE EXISTING SLOPE PROTECTION (18" FACING STONE W/6" FILTER) SALVAGE STONE FOR REUSE.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- [NO.] UTILITY, SEE SHEET 62 FOR TABULATION.
- (NO.) SIDE DRAIN, SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN / HIKING TRAIL.
- NEW ACCESS AND BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- ⊗ SCOUR GAGE SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
914+10	914+16.45	320'TRAP	0.002272	38,000	7.48	10.6	10.5	10.6	10.5
914+16.45	914+66	310'RECT	DROP STRUCTURE						
914+66	917+80	320'TRAP	0.002199	38,000	7.48	10.3	10.9	10.3	10.8
917+80	918+75	320'TRAP	0.002199	38,000	7.48	10.3	10.8	11.4	9.7
918+75	925+46	360'TRAP	0.002199	38,000	7.48	11.4	9.7	11.0	10.1
925+46	927+16	320'TRAP	0.002199	38,000	7.48	11.0	10.1	12.2	9.1
927+16	944+30	320'TRAP	0.002199	38,000	7.48	12.2	9.1	10.9	10.2

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: P. Plenemann

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 914+10 TO STA. 944+30

SUBMITTED BY:

DATE APPROVED:

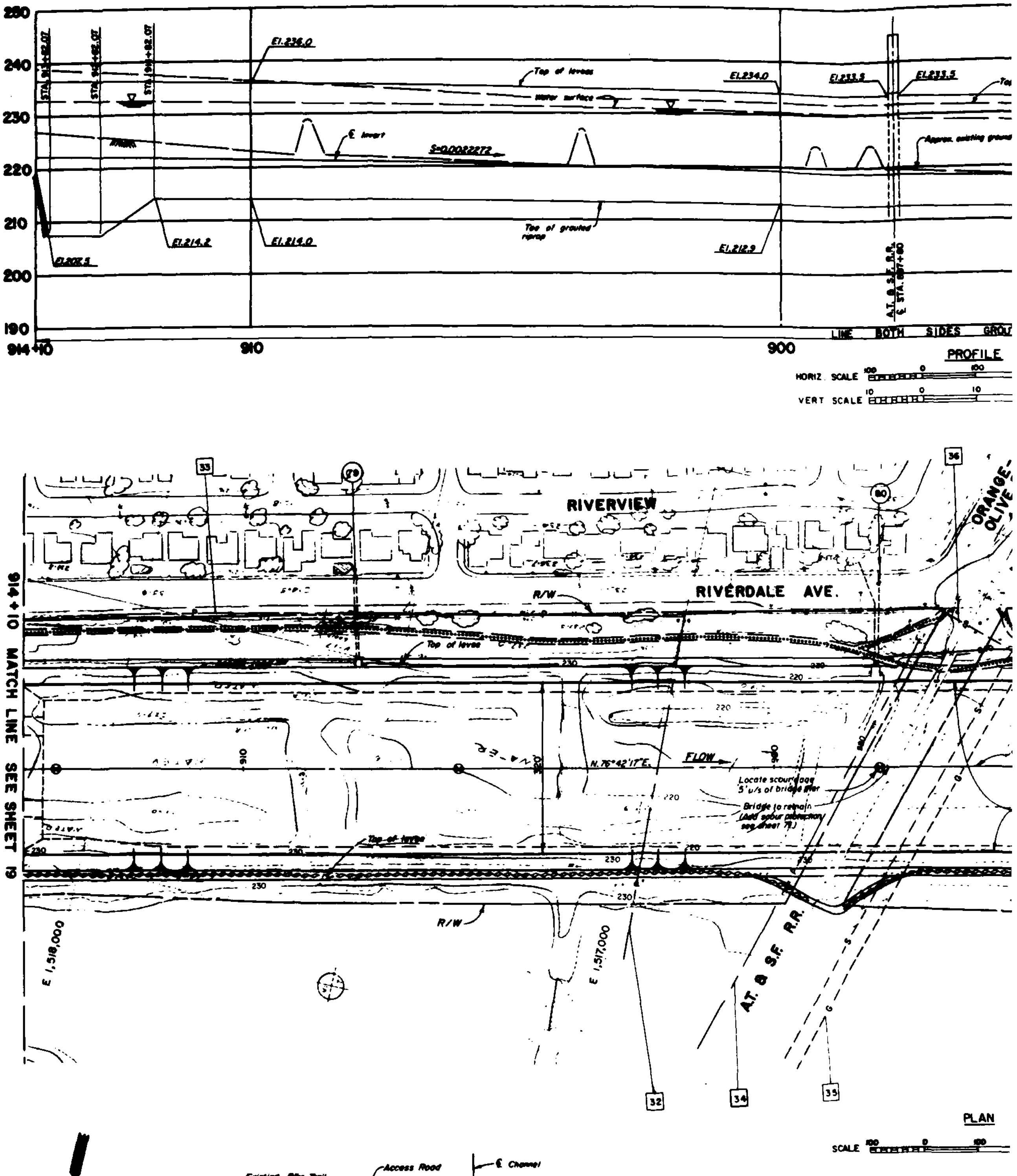
DISTRICT FILE NO.

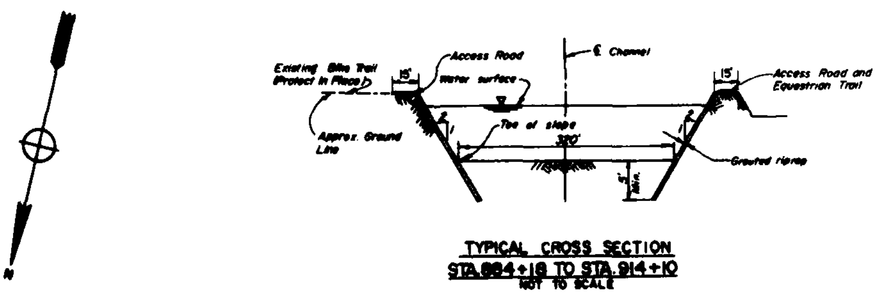
SHEET 19 OF 108 SHEETS

PLATE 22

2

VALUE ENGINEERIN





TYPICAL CROSS SECTION
STA.884+18 TO STA.914+10
NOT TO SCALE

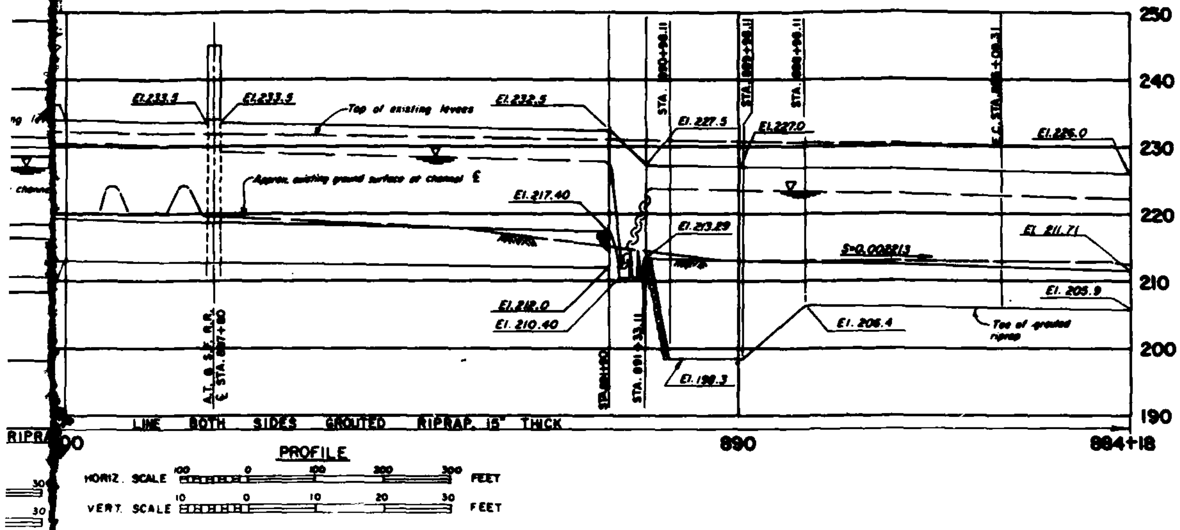
STA.₁ TO STA.₂		SECTIO
884+18	891+40	320'TR
891+40	891+90	310'TR
891+90	897+70	320'TR
897+70	897+90	320'TR
897+90	914+10	320'TR

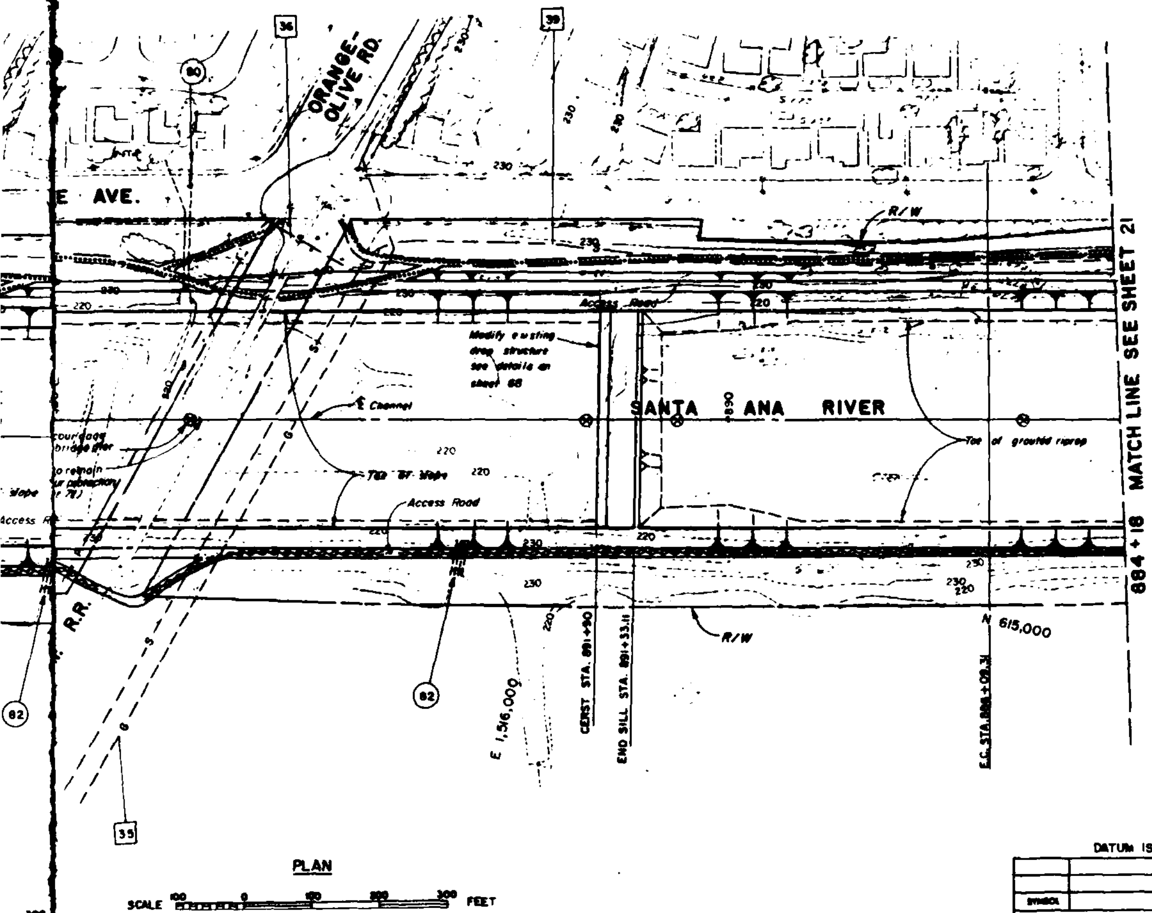
D_1 AND V_1 - DEPTH AND VE

SAFETY PA

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

VALUE ENGINEERING PAYS





NOTE:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (24" FACING STONE W/18" FILTER ON THE RIGHT LEVEE AND 18" FACING STONE W/6" FILTER ON THE LEFT LEVEE).
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- (NO.) UTILITY. SEE SHEET 62 FOR TABULATION
- (NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN / HIKING TRAIL
- NEW ACCESS RD. & BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- ⊗ SCOUR GAGE-SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n=.030			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
884+18	891+40	320' TRAP	0.002213	38,000	7.46	10.7	10.4	10.6	10.5
891+40	891+90	310' RECT.	DROP STRUCTURE						
891+90	897+70	320' TRAP	0.0022272	38,000	7.46	10.3	10.9	10.4	10.8
897+70	897+90	320' TRAP	0.0022272	38,000	7.46	10.4	10.8	11.2	9.9
897+90	914+10	320' TRAP	0.0022272	38,000	7.46	11.2	9.9	10.6	10.5

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: DVLPPS

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA.884+18 TO STA.914+10

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

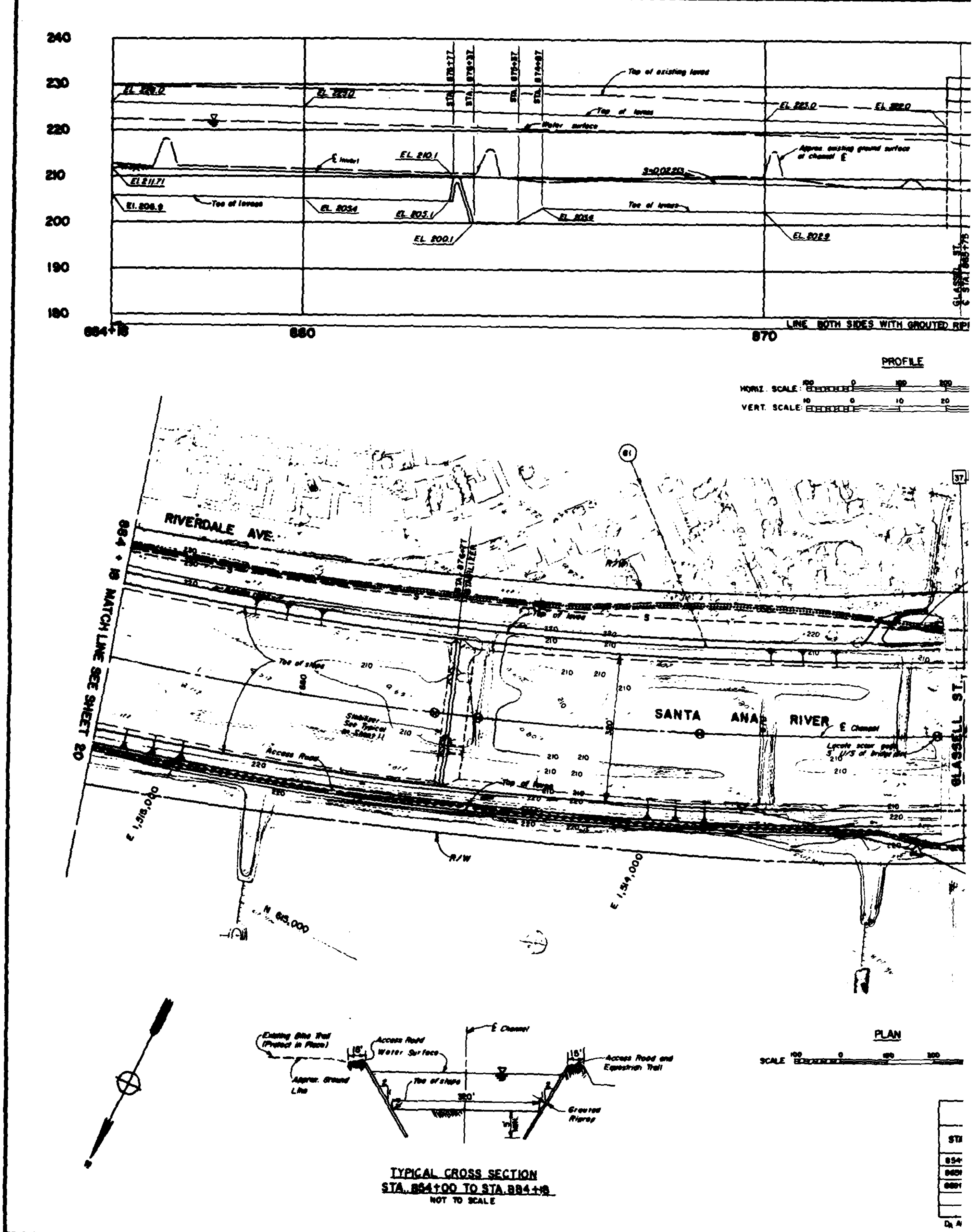
SHEET 20 OF 108 SHEETS

PLATE 23

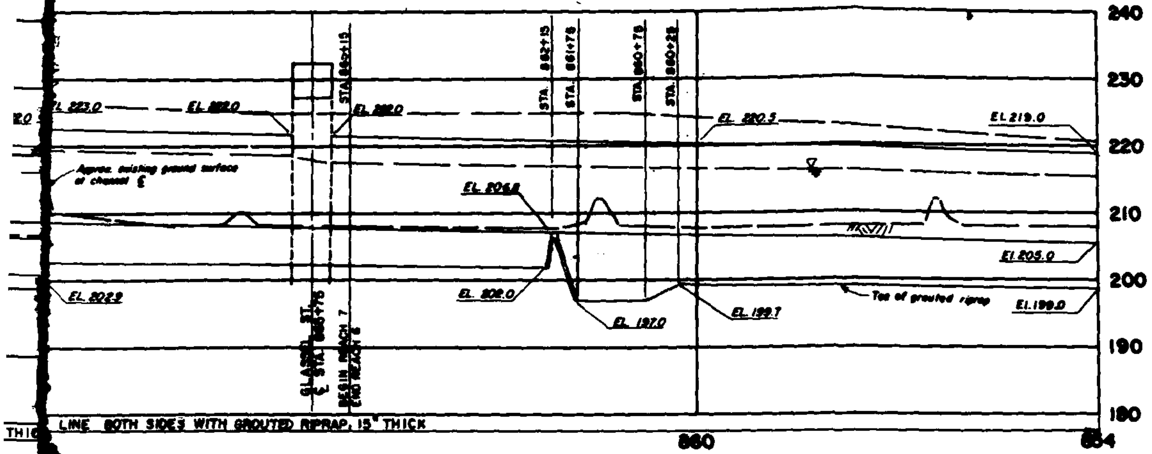
SAFETY PAYS

2

VALUE ENGINEERIN

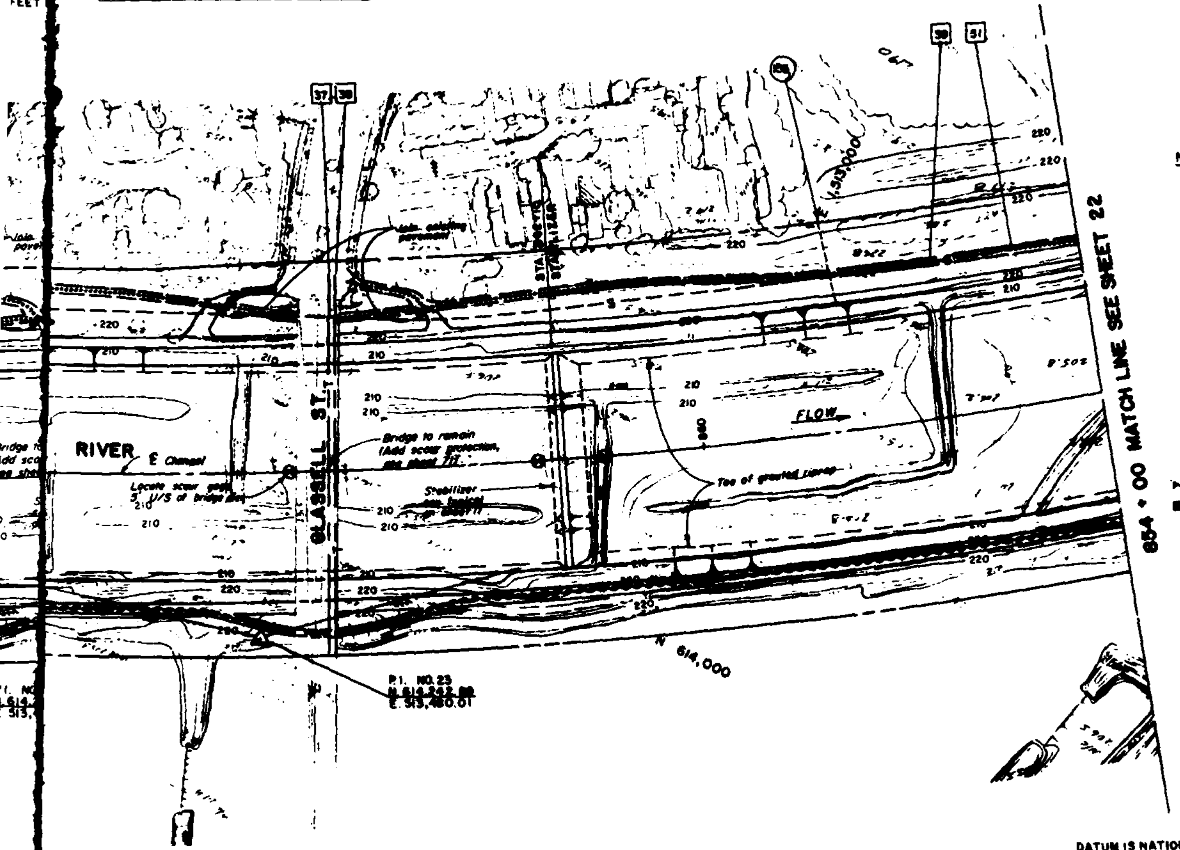


SAFETY PA



PROFILE

PI NO. 23
℄ CURVE DATA
Δ = 27° 54' 53"
R = 8,000'
T = 1,988.30'
L = 3,897.63'



NOTES:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/6" FILTER)
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- UTILITY. SEE SHEET 62 FOR TABULATION
- SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- EXISTING BIKE TRAIL- PROTECT IN PLACE
- SCOUR GAGE-SEE SHEET 9 FOR DETAIL

PLAN

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
854+00	[illegible]	380' TRAP	0.002213	38,000	7.48	10.5	10.6	10.5	10.6
[illegible]	[illegible]	380' TRAP	0.002213	38,000	7.48	10.5	10.6	11.5	9.6
[illegible]	[illegible]	380' TRAP	0.002213	38,000	7.48	11.5	9.6	10.7	10.4

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

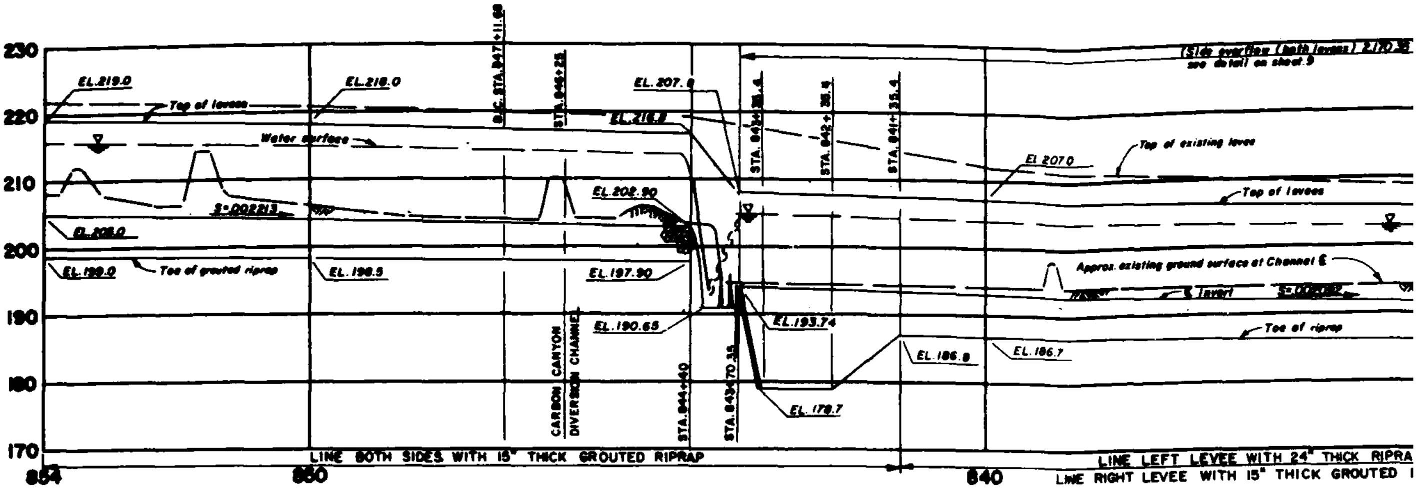
REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 854+00 TO STA. 884+18

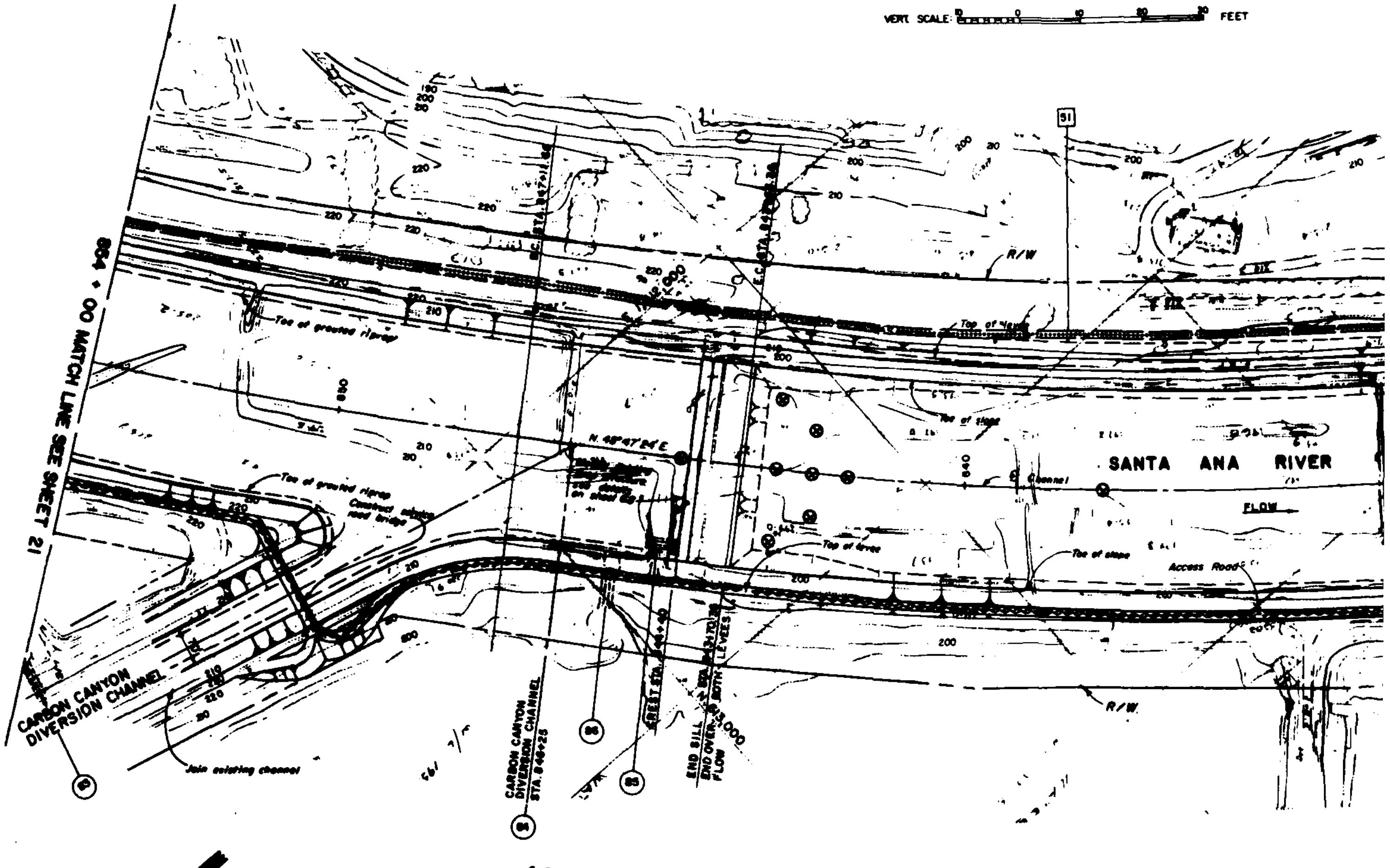
SUBMITTED BY: DATE APPROVED:
DISTRICT FILE NO.
SHEET 21 OF [illegible]



PROFILE

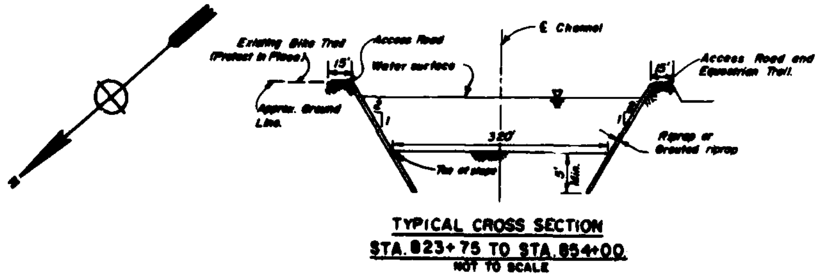
HORIZ. SCALE: 100 0 100 200 300 FEET

VERT. SCALE: 10 0 10 20 30 FEET



PLAN

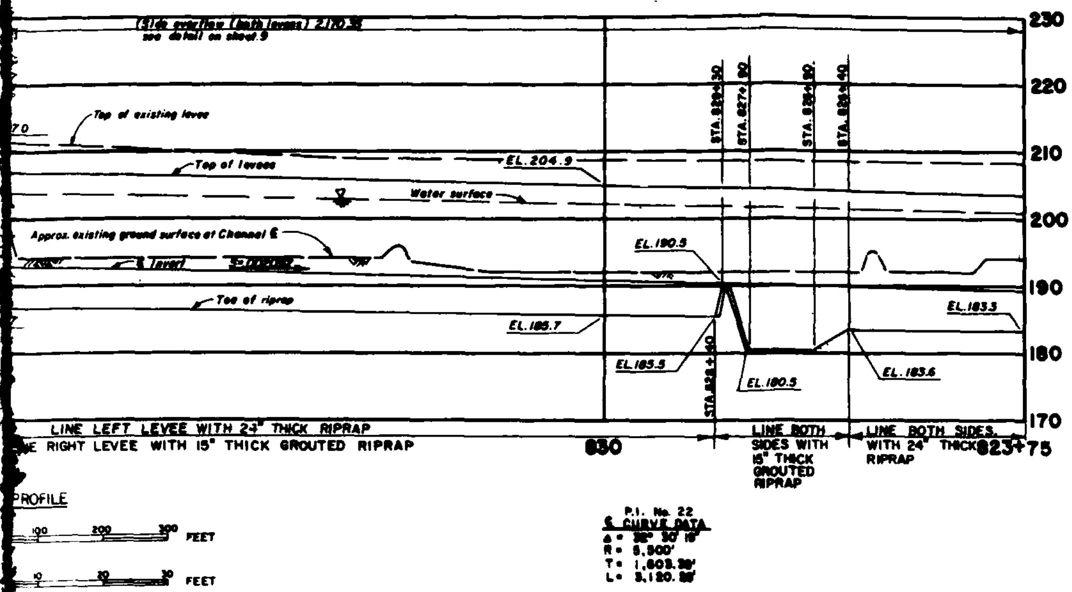
SCALE 100 0 100 200 300 FEET

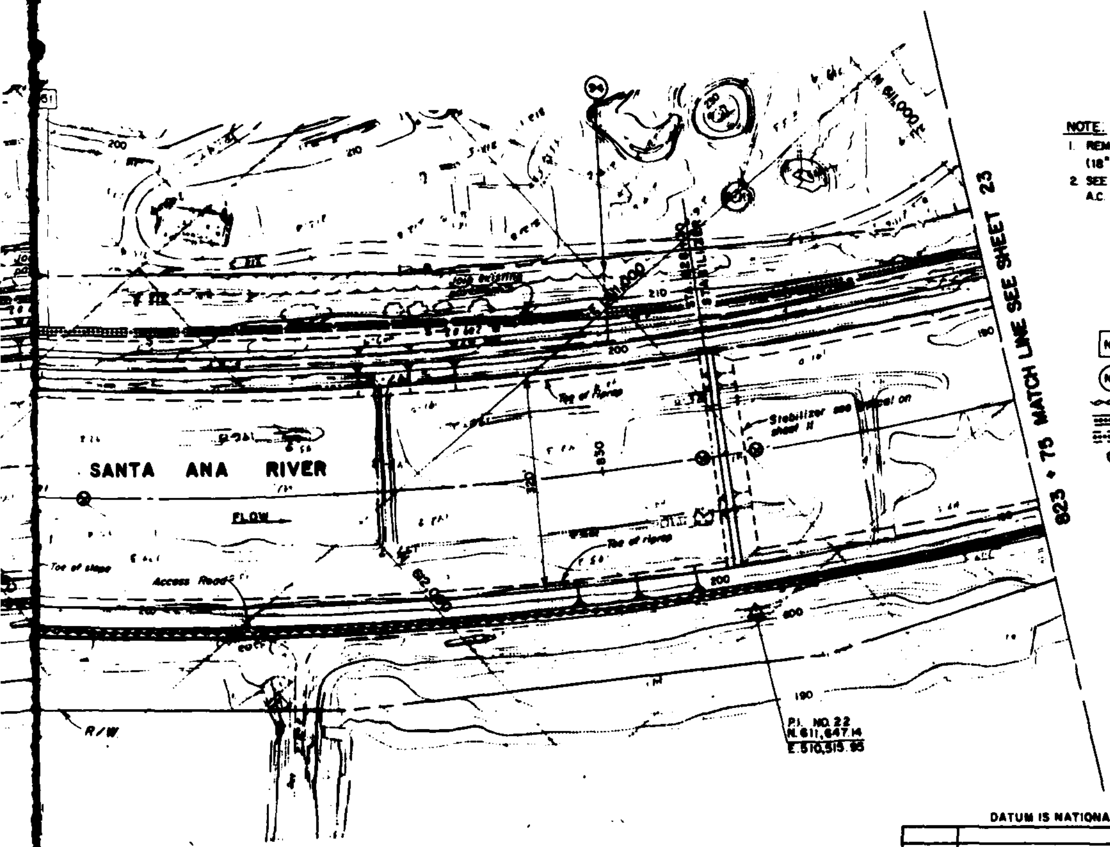


TYPICAL CROSS SECTION
STA. 823+75 TO STA. 854+00
NOT TO SCALE

STA. TO
823+75
843+90
844+40
849+50

D_A AND V





NOTE:
1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/ 6" FILTER).
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

NO.	UTILITY, SEE SHEET 62 FOR TABULATION
(NO.)	SIDE DRAIN SEE SHEET 70 FOR DETAILS
	EQUESTRIAN / HIKING TRAIL
	NEW RELOCATED BIKE TRAIL
	EXISTING BIKE TRAIL - PROTECT IN PLACE
⊗	SCOUR GAGE-SEE SHEET 9 FOR DETAIL

PLAN

100 200 300 FEET

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	Q (cfs)	D_c (ft)	n = .030 D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
823+75	843+90	280' TRAP	0.002092	40,000	7.74	11.4	10.2	11.2	10.5
843+90	844+40	310' REC DROP STRUCTURE							
844+40	847+50	280' TRAP	0.002213	40,000	7.74	10.6	11.0	10.7	11.0
849+50	854+00	280' TRAP	0.002213	38,000	7.48	10.5	10.6	10.5	10.6

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: F.CEDEÑO/ P. VILPPU

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 823+75 TO STA. 854+00

SUBMITTED BY:

DATE APPROVED:

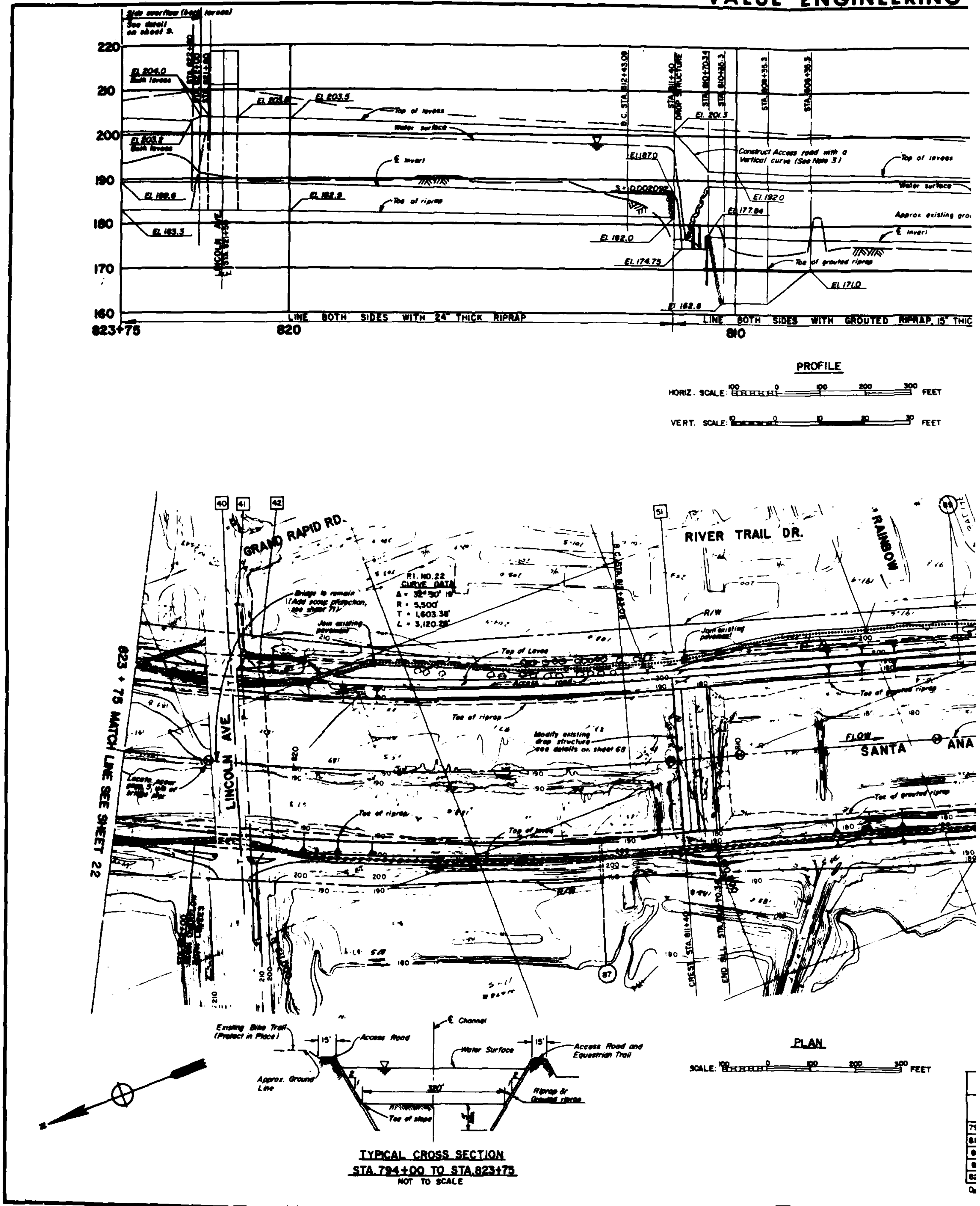
DISTRICT FILE NO.

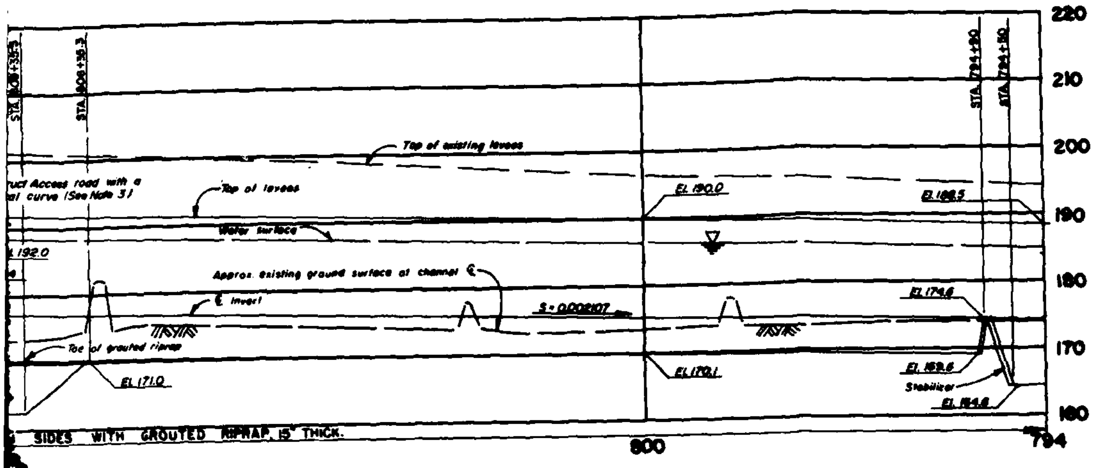
SHEET 22 OF 108 SHEETS

PLATE 25

2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





PROFILE

0 100 200 300 FEET

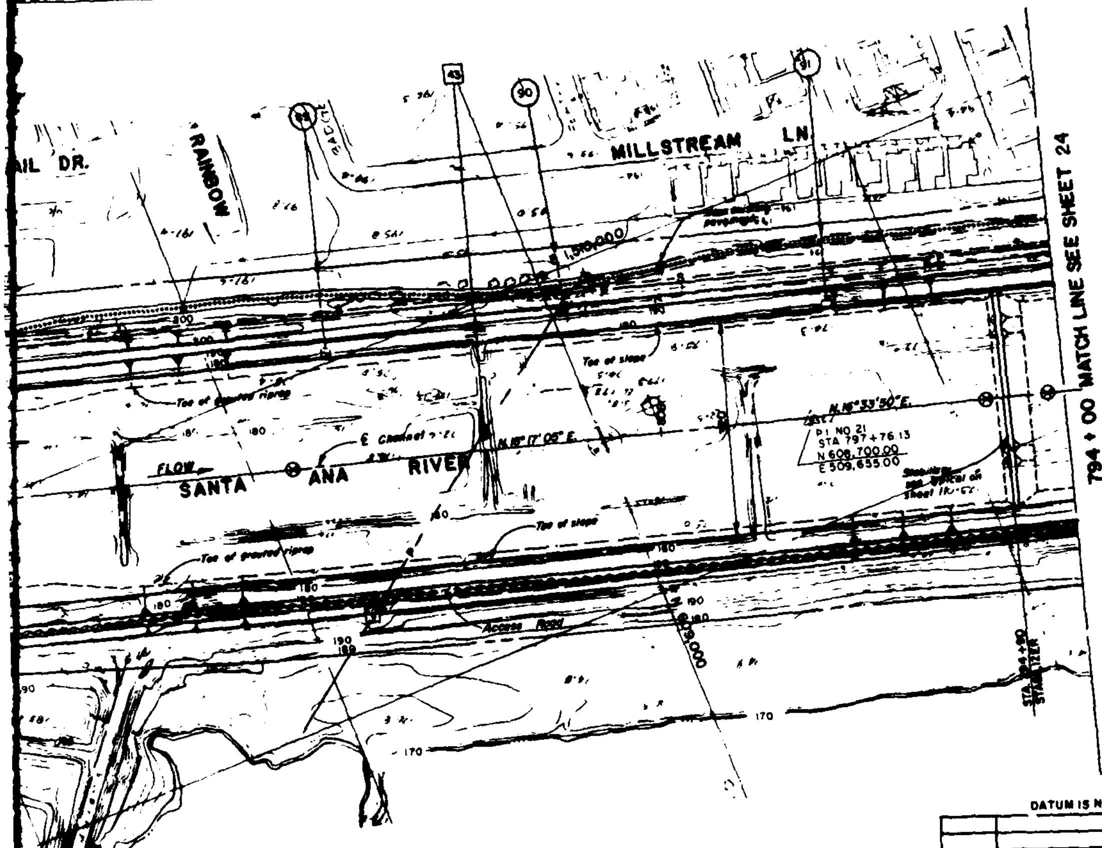
0 10 20 30 FEET

NOTES:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/O 6" FILTER.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.
3. ACCESS ROADS WILL BE CONSTRUCTED WITH A MAXIMUM VERTICAL GRADE OF 10% AND A 90-FOOT MINIMUM LENGTH ON ANY VERTICAL CURVE.

LEGEND

- (NO.) UTILITY SEE SHEET 62 FOR TABULATION.
- (NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN/HIKING TRAIL
- NEW ACESS RD. & BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- SCOUR GAGE-SEE SHEET 9 FOR DETAIL



PLAN

0 100 200 300 FEET

HYDRAULIC ELEMENTS									
STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .050			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
794+00	810+90	320'TRAP	0.002107	40,000	7.74	11.0	10.6	11.0	10.6
810+90	811+40	320'RECT	DROP STRUCTURE						
811+40	821+15	320'TRAP	0.003082	40,000	7.74	10.6	11.0	11.0	10.7
821+15	821+85	320'TRAP	0.003082	40,000	7.74	11.0	10.7	11.5	10.2
821+85	823+75	320'TRAP	0.003082	40,000	7.74	11.5	10.2	11.4	10.2

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: D. TILPPU
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 794+00 TO STA. 823+75

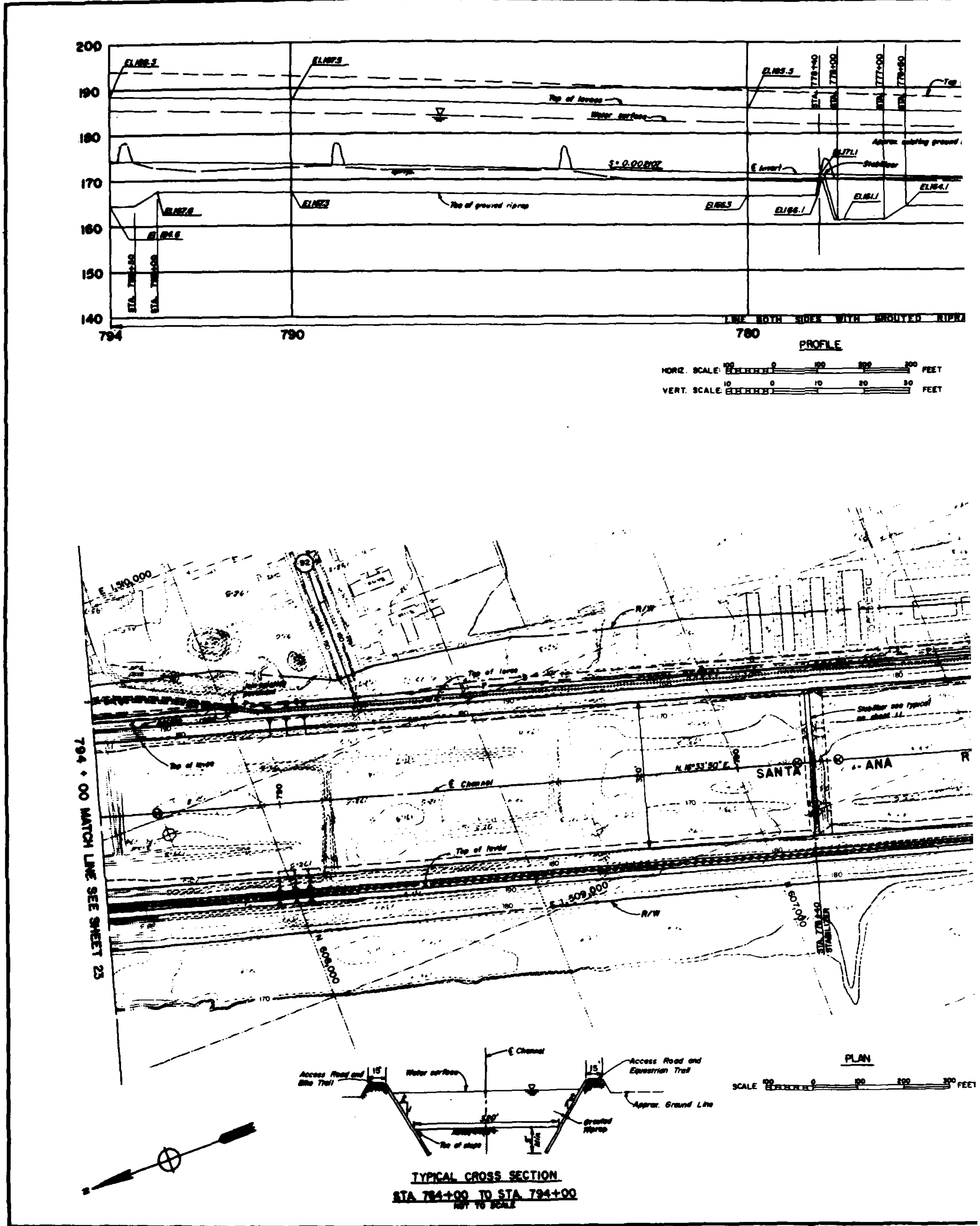
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

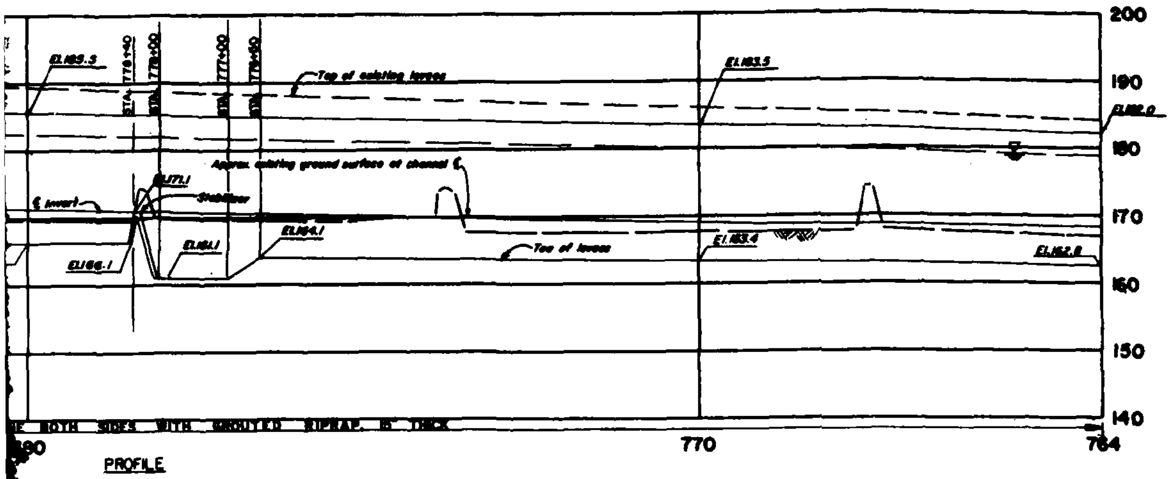
SHEET 23 OF 106 SHEETS

PLATE 86

R

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



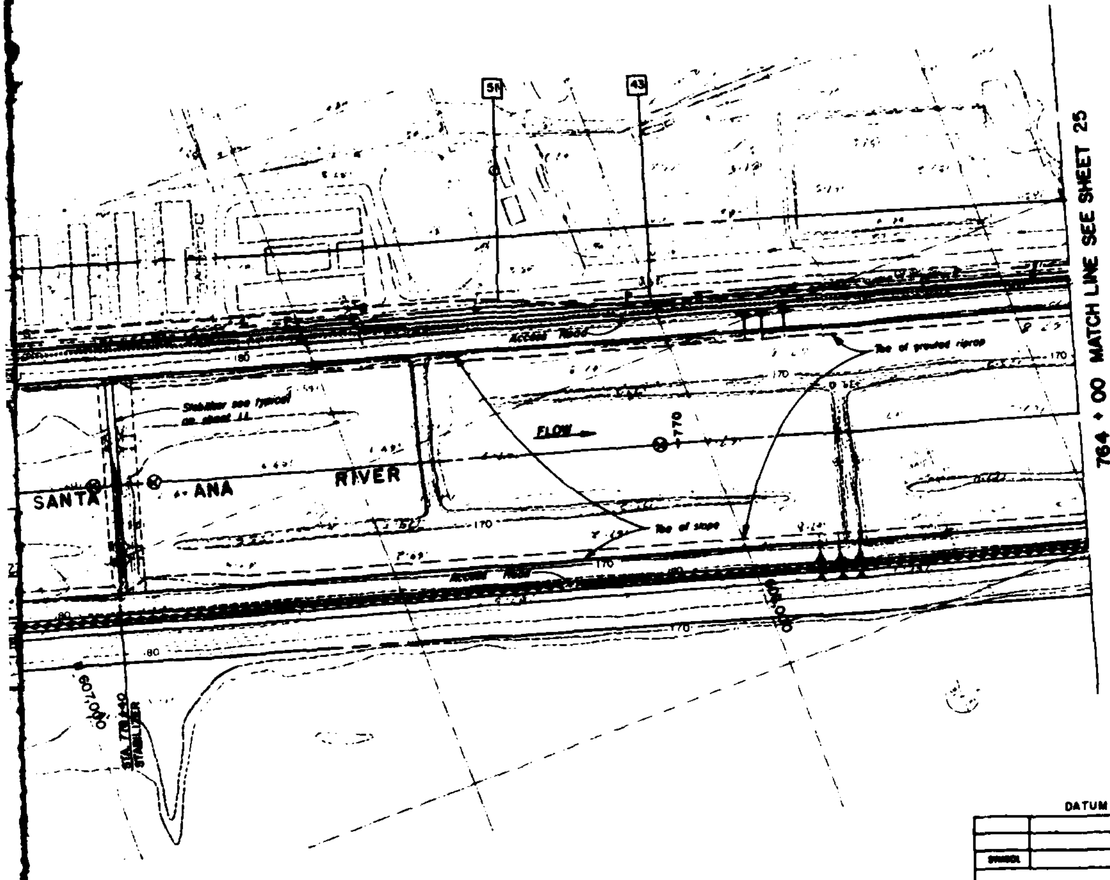


PROFILE

FEET

FEET

NOTE:
1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/ 6" FILTER)
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.



LEGEND

- UTILITY. SEE SHEET 62 FOR TABULATION.
- SIDE DRAIN. SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN HIKING TRAIL.
- NEW ACCESS ROAD AND BIKE TRAIL.
- EXISTING BIKE TRAIL - PROTECT IN PLACE.
- SCOUR GAGE - SEE SHEET 9 FOR DETAIL.

PLAN

FEET

HYDRAULIC ELEMENTS										
STA. TO STA.		SECTION	DESIGN SLOPE	Q (cfs)	Dc (FT)	n = .030			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
764+00	794+00	380' TRAP	0.002107	40,000	7.7	11.0	10.6	11.0	10.6

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: H.S.
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

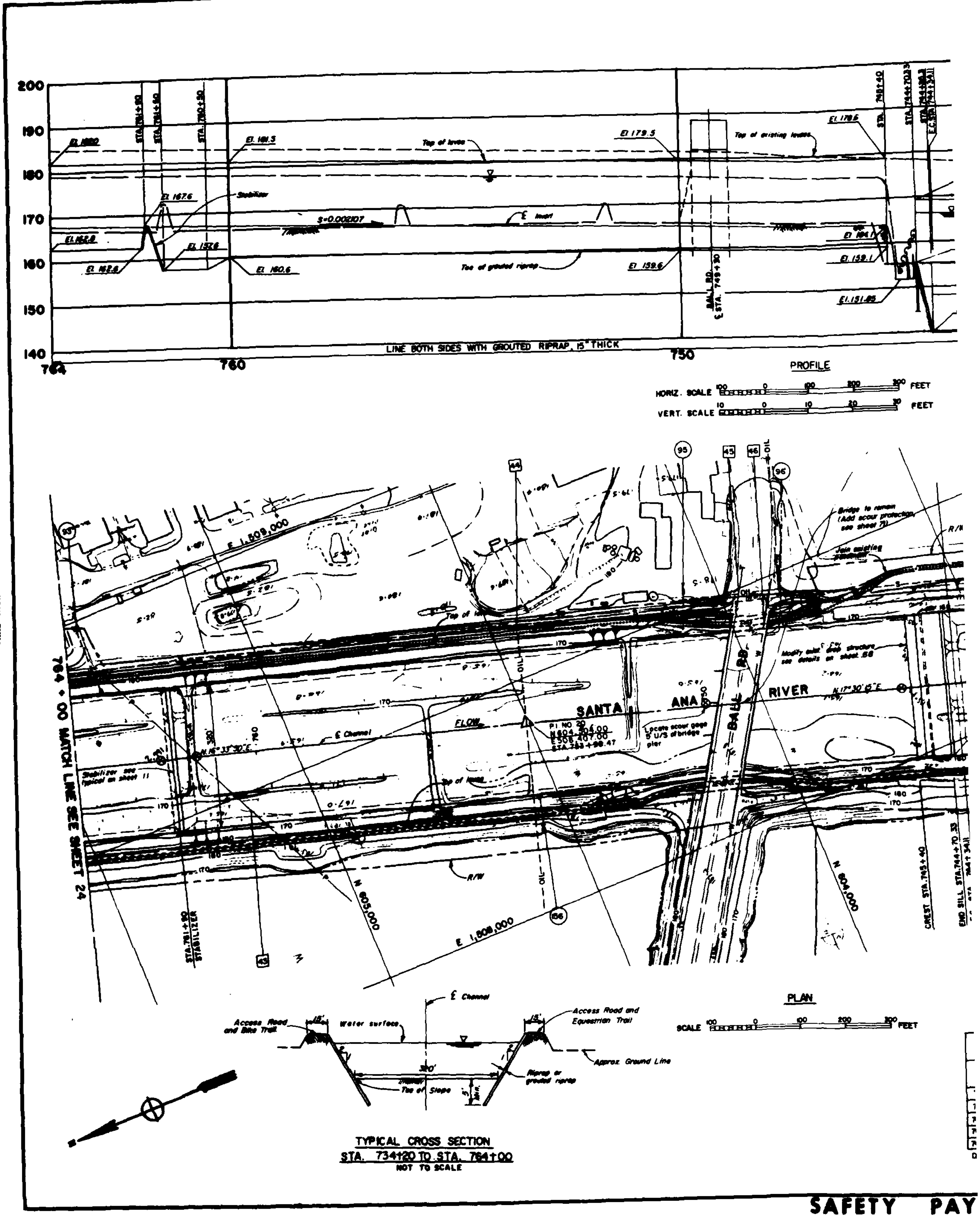
LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA 764+00 TO STA. 794+00

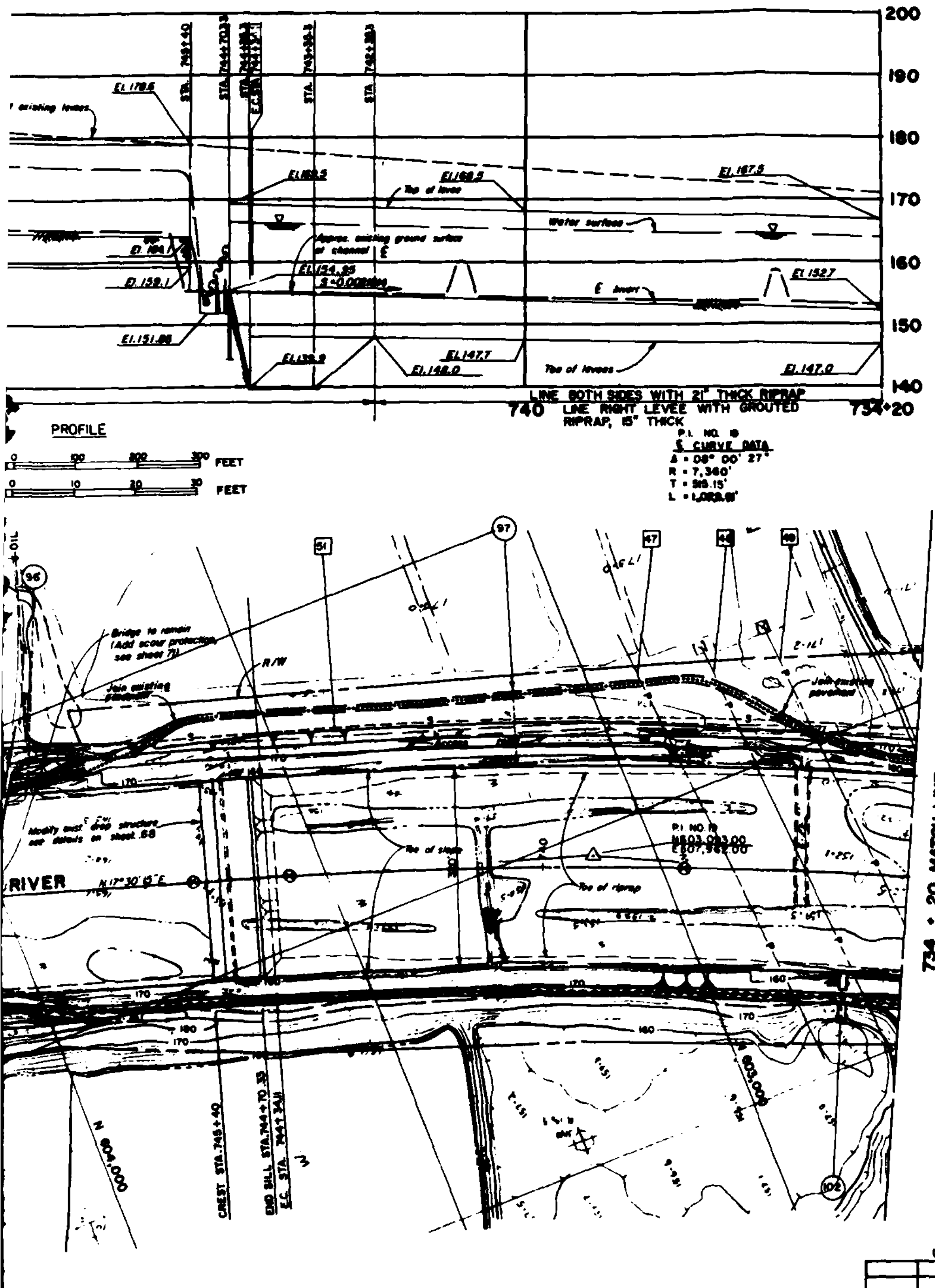
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 24 OF 66

PLATE 27

2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





PLAN

FEET

NOTES:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/6" FILTER)
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C PAVING DETAILS

LEGEND

- NO. UTILITY SEE SHEET 62 FOR TABULATION
- NO. SIDE DRAIN SEE SHEET 70 FOR DETAILS
- EQUESTRIAN / HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- SCOUR GAGE - SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA.$_1$	TO STA.$_2$	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .03			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
734+20	744+90	380' TRAP	0.002181	40,000	7.7	11.9	9.8	11.3	10.4
744+90	745+40	310' RECT	DROP STRUCTURE	40,000					
745+40	748+90	380' TRAP	0.002107	40,000	7.7	10.6	11.0	10.7	10.9
748+90	749+75	380' TRAP	0.002107	40,000	7.7	10.7	10.9	11.3	10.4
749+75	764+00	380' TRAP	0.002107	40,000	7.7	11.3	10.4	11.0	10.6

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

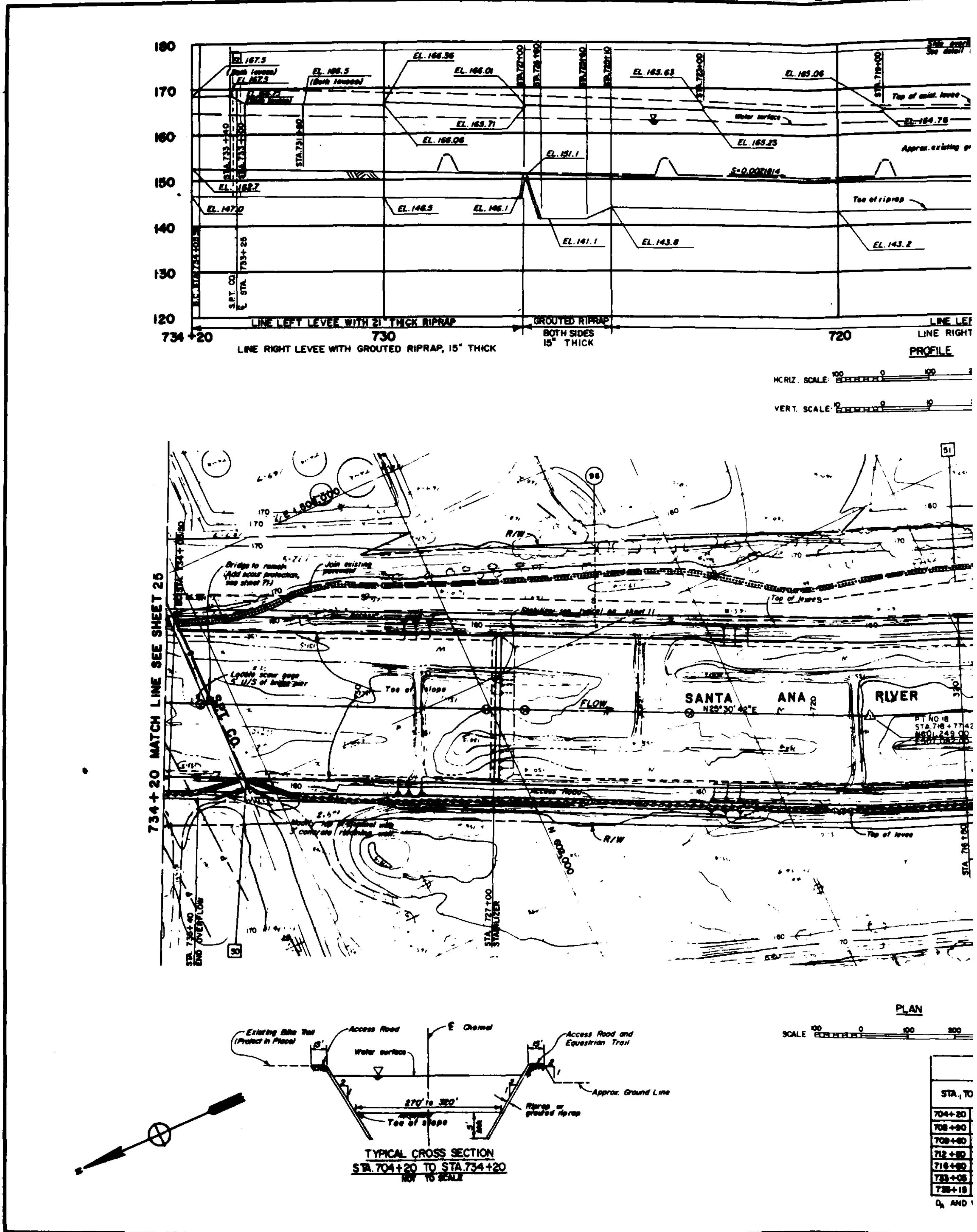
SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 734+20 TO STA. 764+00

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 25 OF 106 SHEETS

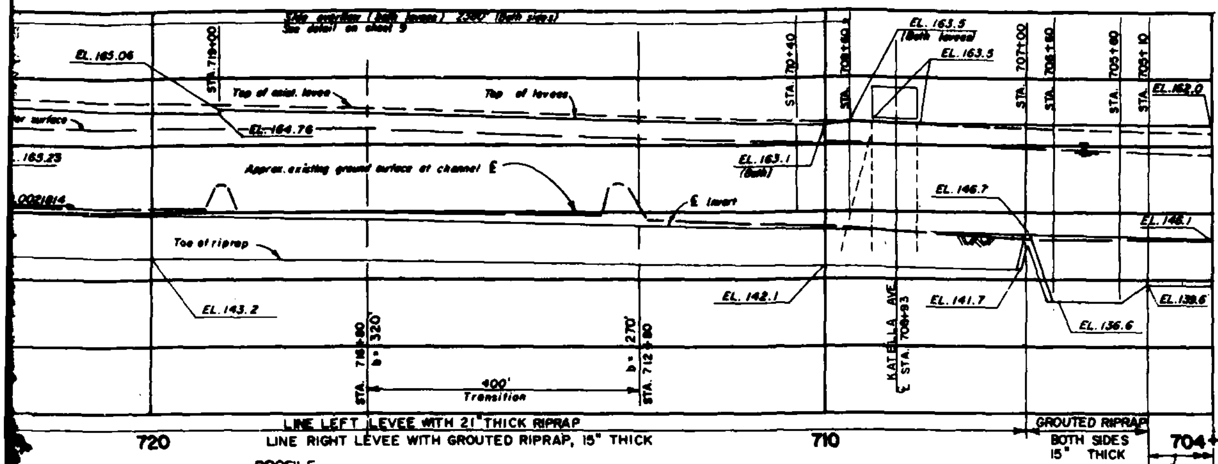
PLATE 28

VALUE ENGINEERING



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY PAY

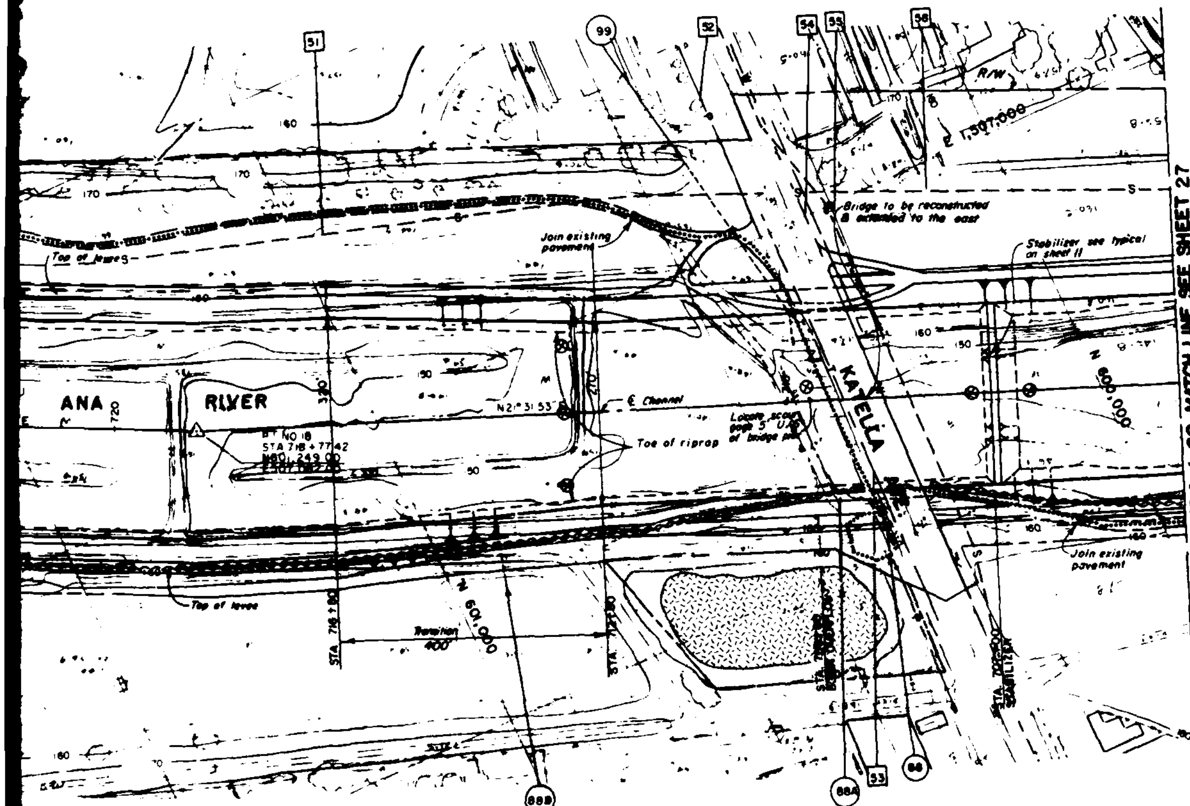


LINE LEFT LEVEE WITH 21" THICK RIPRAP AND LINE RIGHT LEVEE WITH GROUTED RIRAP, 15" THICK.

PROFILE

HORIZ. SCALE 100 0 100 200 300 FEET

VERT. SCALE 10 0 10 20 30 FEET



NOTES

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/6" FILTER)
2. D/S OF KATELLA REMOVE 6" REINFORCED CONCRETE FROM SIDE SLOPES.
3. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- NO. — UTILITY. SEE SHEET 62 FOR TABULATION.
- (NO.) — SIDE DRAIN SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS RD. AND BIKE TRAIL
- EXISTING BIKE TRAIL–PROTECT IN PLACE
- DESIGNATED PONDING AREA
- ⊗ SCOUR GAGE–SEE SHEET 9 FOR DETAIL
- ADDITIONAL R/W REQUIRED

PLAN

SCALE 100 0 100 200 300 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

HYDRAULIC ELEMENTS

STA.1 TO STA.2		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
704+20	708+80	270'TRAP	0.002161	40,000	8.6	12.9	10.5	12.6	10.8
708+80	709+60	270'TRAP	0.002161	40,000	8.6	12.6	10.8	13.1	10.3
709+60	712+80	270'TRAP	0.002161	40,000	8.6	13.1	10.3	12.9	10.8
712+80	716+80	[illegible]	0.002161	40,000	VARIES	12.9	10.8	13.1	8.8
716+80	733+08	320'TRAP	0.002161	40,000	7.7	13.1	8.8	11.6	10.1
733+08	733+18	320'TRAP	0.002161	40,000	7.7	11.6	10.1	12.0	9.7
733+18	734+80	320'TRAP	0.002161	40,000	7.7	12.0	9.7	11.9	9.8

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 704+20 TO STA. 734+20

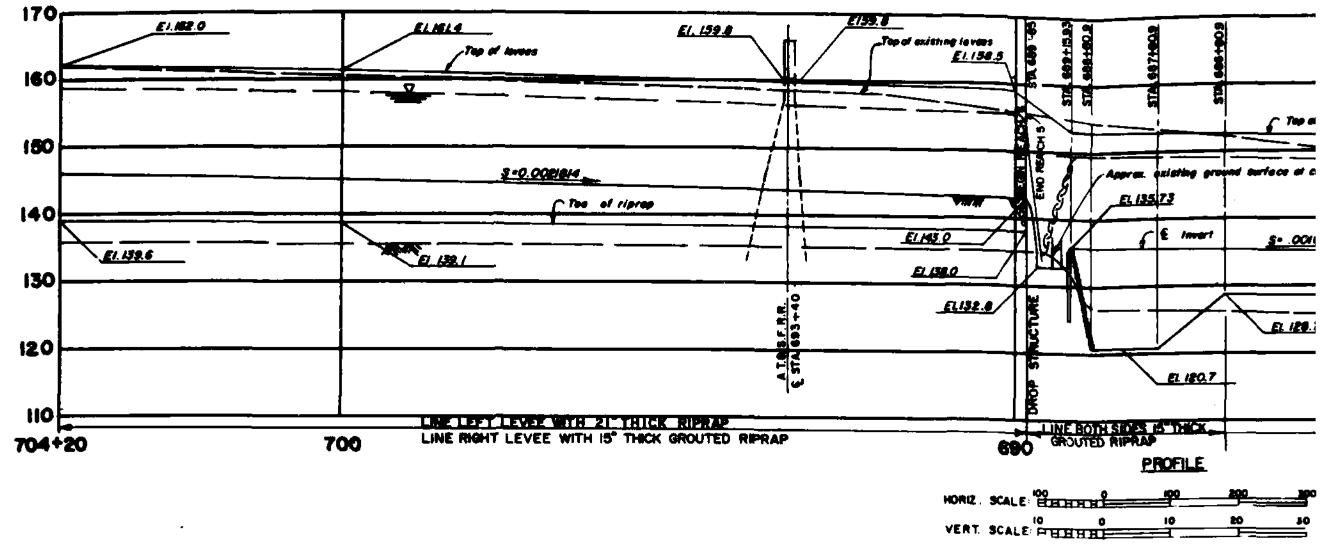
DATE APPROVED:
DISTRICT FILE NO.

SHEET 28 OF 108 SHEETS

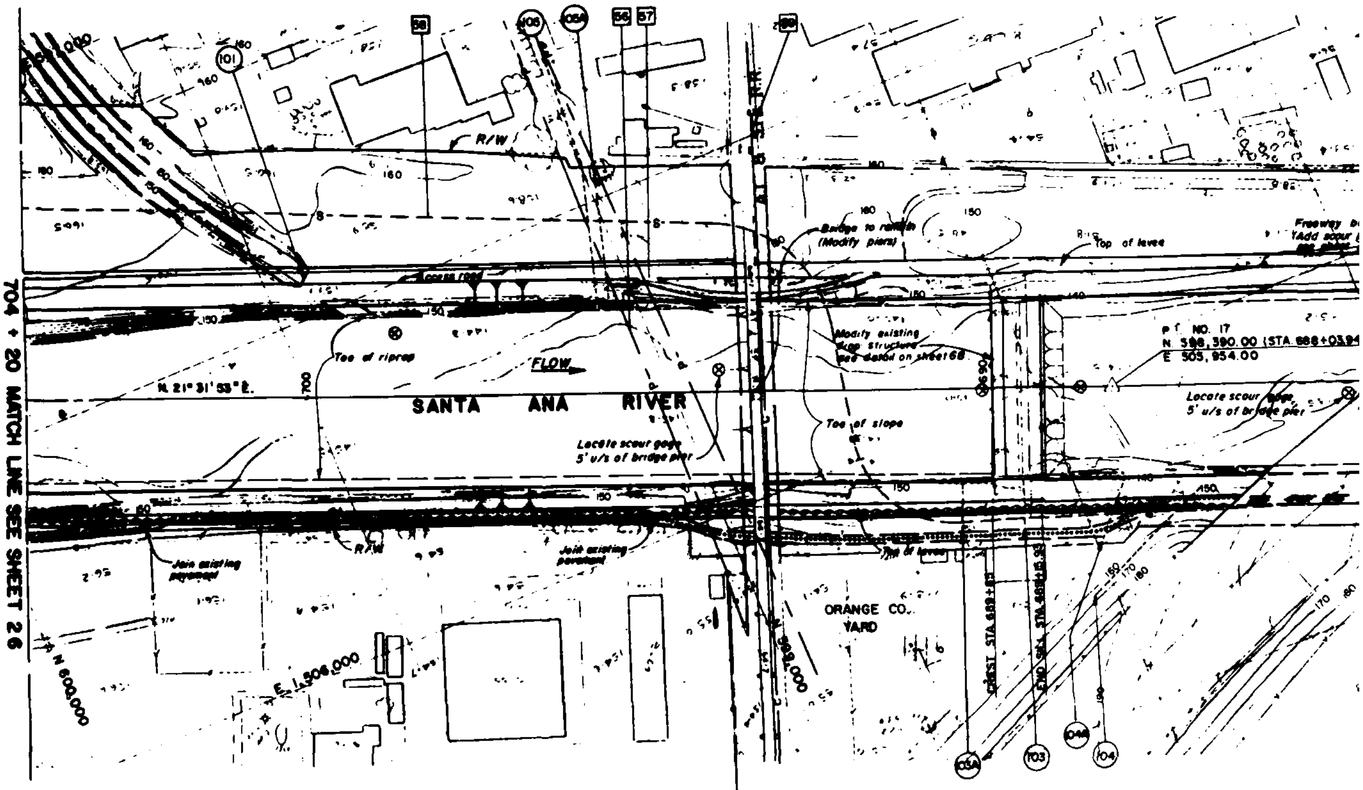
PLATE 29

/

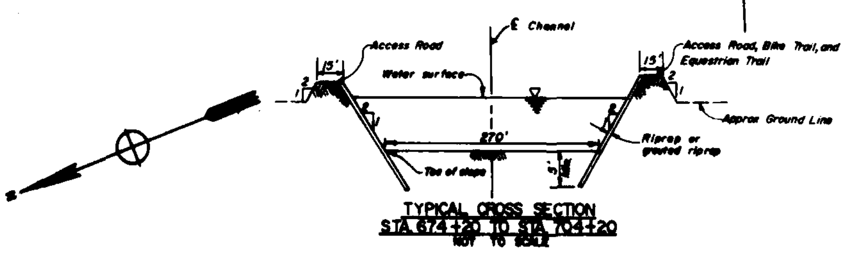
2



PROFILE



PLAN



TYPICAL CROSS SECTION
STA 674+20 TO STA 704+20
NOT TO SCALE

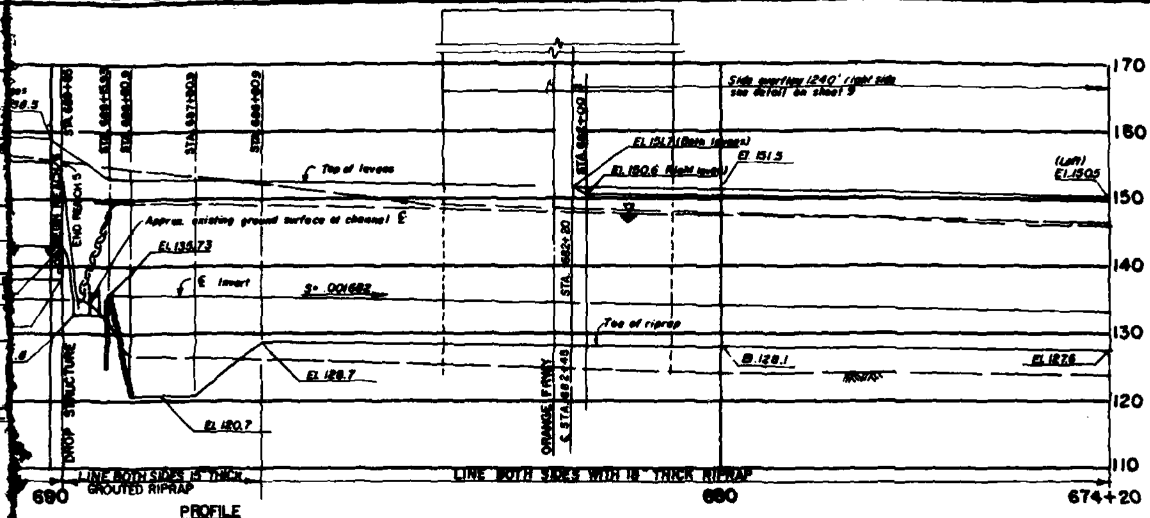
STA.₁ TO STA.₂		SECTION	DESIG SLOP
674+20	680+70	270' TRAP	0.00
680+70	684+10	270' TRAP	0.00
684+10	689+35	270' TRAP	0.00
689+35	689+85	260' RECT	DROP S
689+85	693+40	270' TRAP	0.002
693+40	693+80	270' TRAP	0.002
693+80	704+20	270' TRAP	0.002

D_A AND V_A = DEPTH AND VELOCIT

SAFETY PA

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

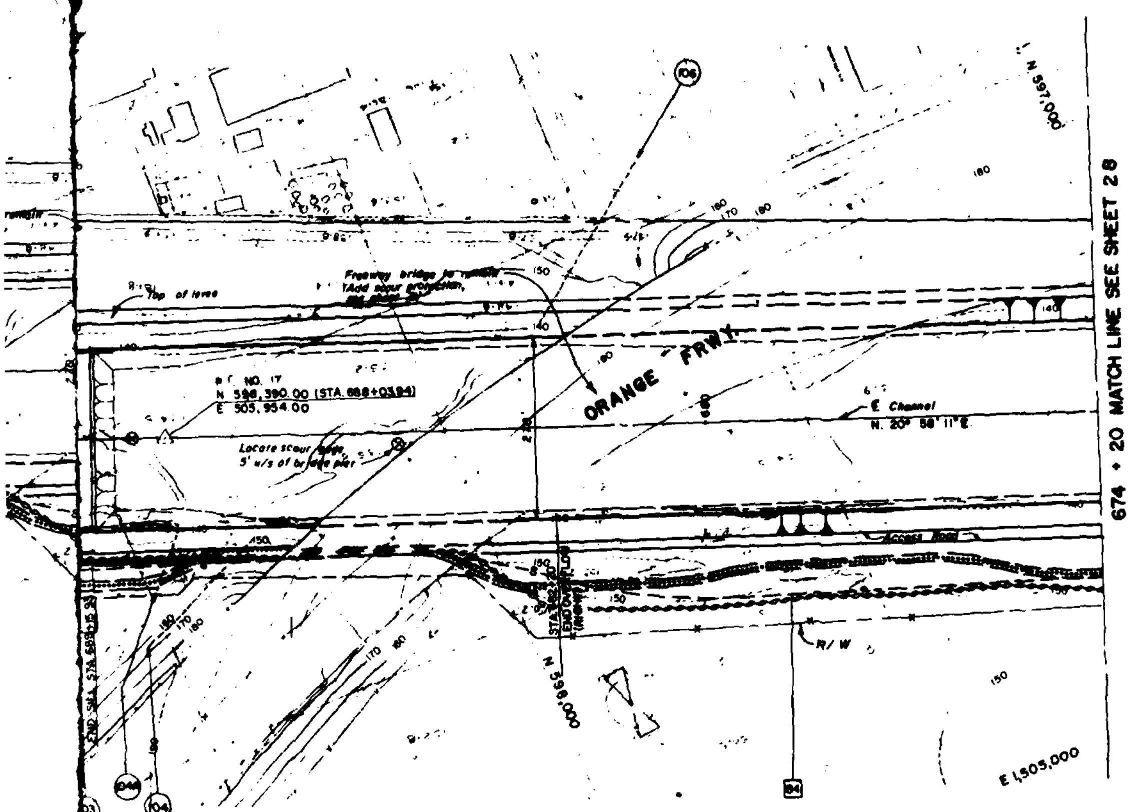
VALUE ENGINEERING PAYS



PROFILE

SCALE: 100 0 100 200 300 FEET

SCALE: 10 0 10 20 30 FEET



PLAN

SCALE 100 0 100 200 300 FEET

NOTE:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/6" FILTER).
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C PAVING DETAILS.

LEGEND

- NO. UTILITY. SEE SHEET 62 FOR TABLATOR
- NO. SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN / HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL - PROTECT IN PLACE
- ⊗ SCOUR GAGE - SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = 0.30			
						D_{a_1}	V_{a_1}	D_{a_2}	V_{a_2}
674+20	680+70	270' TRAP	0.001682	41,000	8.8	13.4	10.3	13.3	10.4
680+70	684+10	270' TRAP	0.001682	41,000	8.8	13.3	10.4	13.7	10.0
684+10	689+35	270' TRAP	0.001682	41,000	8.8	13.7	10.0	13.6	10.2
689+35	689+65	260' RECT	DROP STRUCT						
689+65	693+40	270' TRAP	0.002181	41,000	8.8	12.6	11.1	12.4	11.2
693+40	698+80	270' TRAP	0.002181	41,000	8.8	12.4	11.8	13.5	10.3
698+80	704+20	270' TRAP	0.002181	40,000	8.8	13.6	10.3	12.9	10.6

D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: | DRAWN BY: | CHECKED BY:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 674+20 TO STA. 704+20

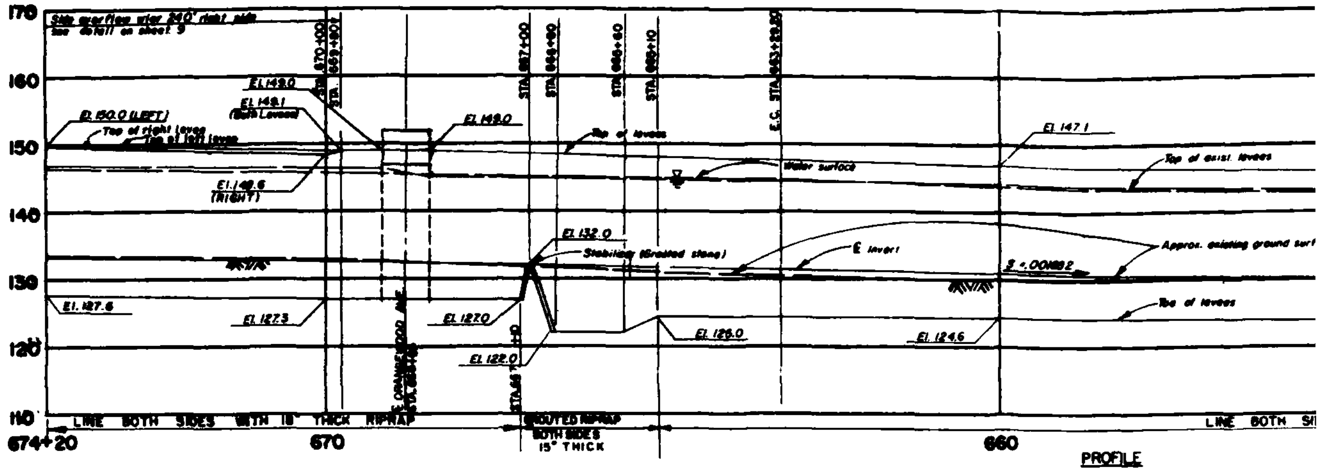
SUBMITTED BY: | DATE APPROVED: | DISTRICT FILE NO.

SHEET 27 OF 108 SHEETS

PLATE 20

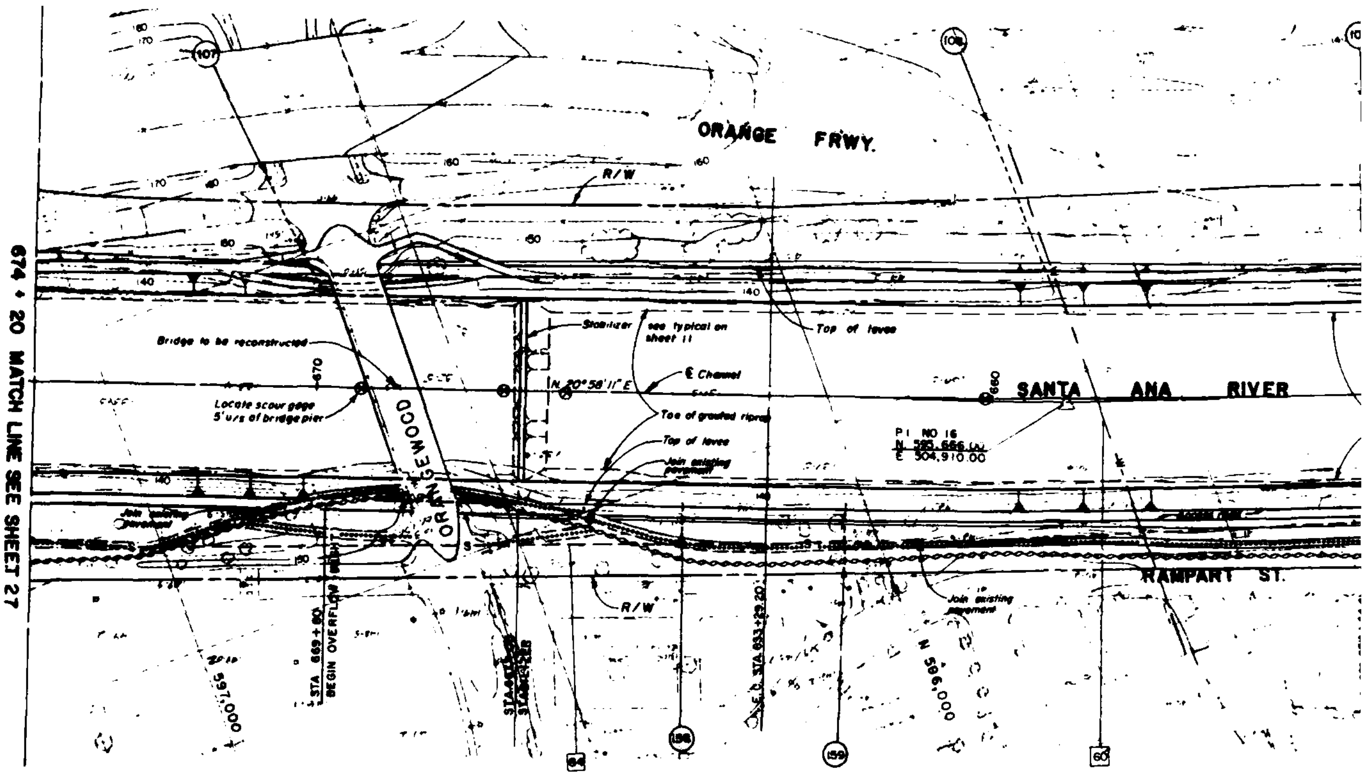
SAFETY PAYS

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



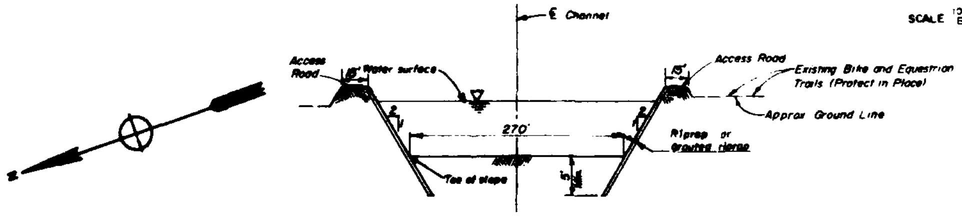
PROFILE

HORIZ. SCALE 100 0 100 200 300 FEET
VERT. SCALE 10 0 10 20 30 FEET



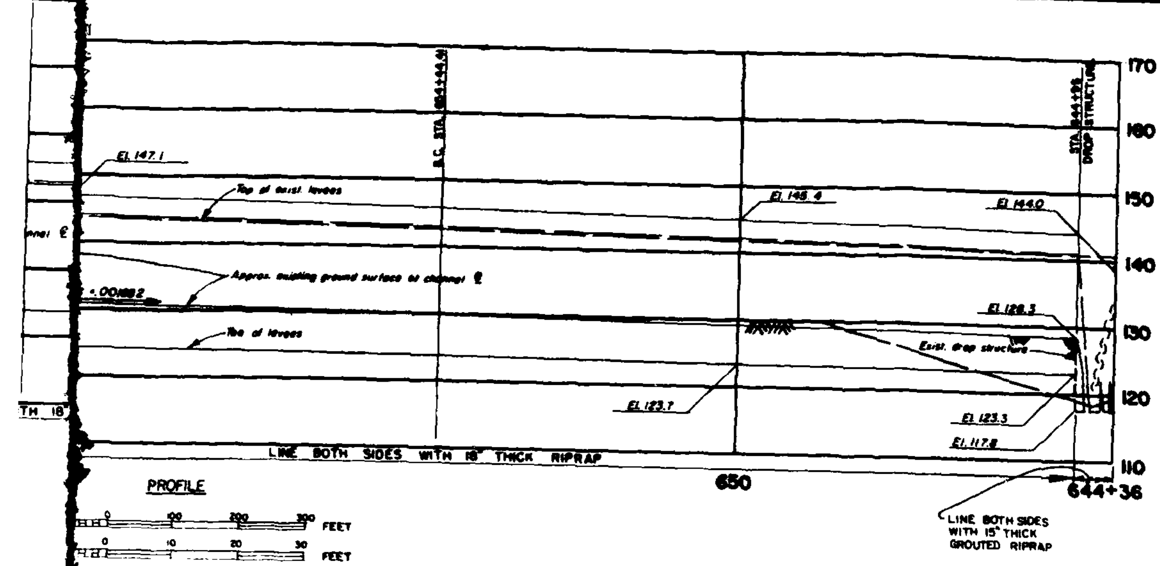
PLAN

SCALE 100 0 100 200 300 FEET

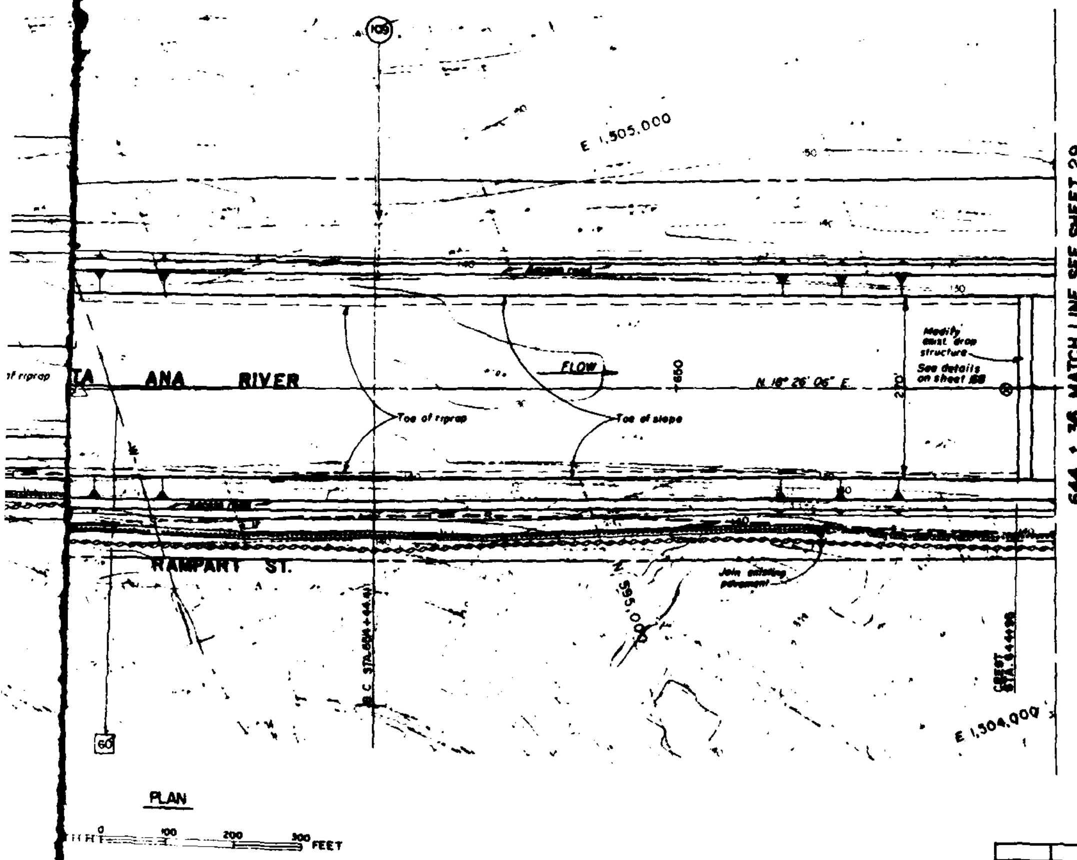


TYPICAL CROSS SECTION
STA.664+95 TO STA.674+20
NOT TO SCALE

VALUE ENGINEERING PAYS



PROFILE



PLAN

NOTES:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/6" FILTER)
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- NO. UTILITY SEE SHEET 62 FOR TABULATION.
- NO. SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL.
- NEW ACCESS RD. AND BIKE TRAIL.
- EXISTING BIKE TRAIL-PROTECT IN PLACE.
- ⊗ SCOUR GAGE-SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA_1 TO STA_2		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{a_1}	V_{a_1}	D_{a_2}	V_{a_2}
644+36	644+95	PROJECT DROP STRUCTURE							
644+95	668+90	270'TRAP	0.001682	41,000	8.8	12.5	11.1	13.1	10.8
668+90	669+20	270'TRAP	0.001682	41,000	8.8	13.1	10.6	13.6	10.2
669+20	674+20	270'TRAP	0.001682	41,000	8.8	13.5	10.2	13.4	10.3

D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: XAA
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

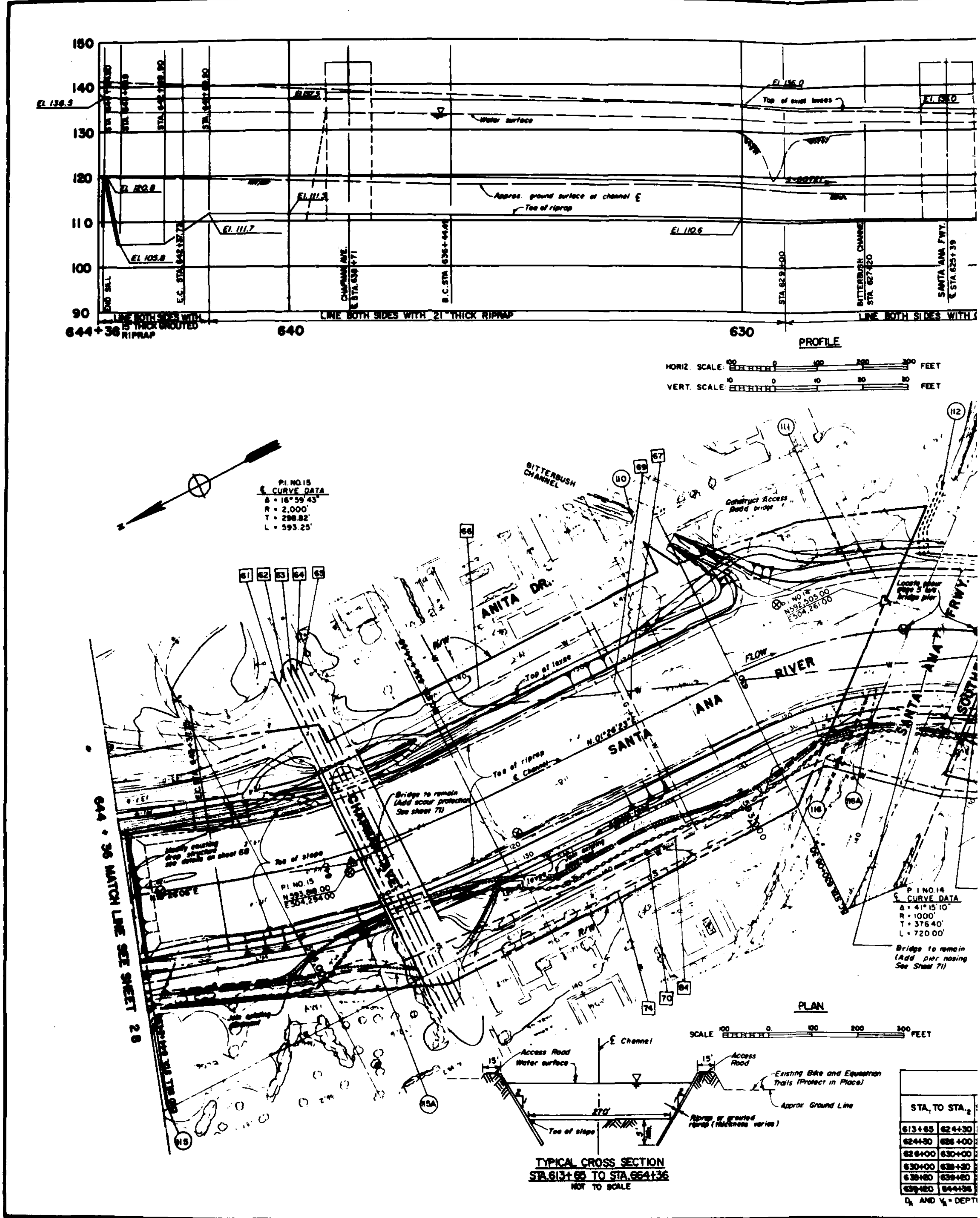
LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 644+36 TO STA. 674+20

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 28 OF 100 SHEETS
PLATE 3

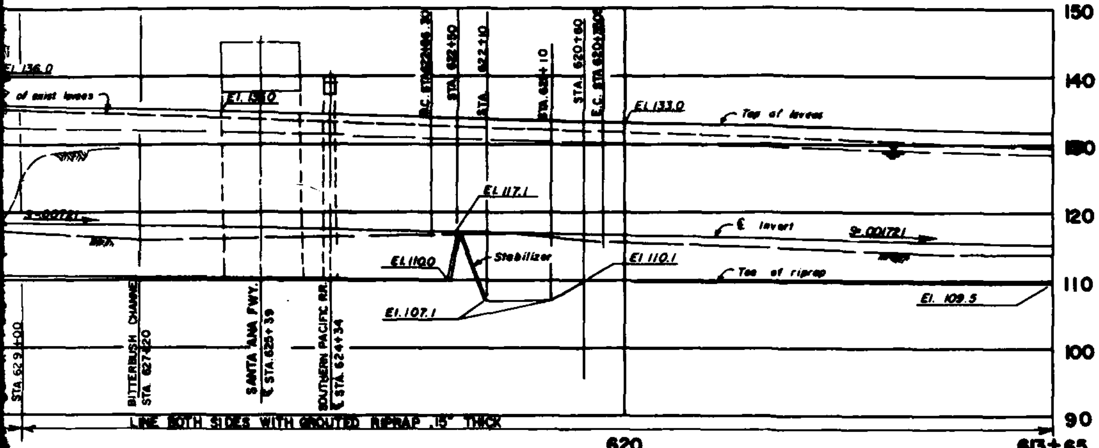
SAFETY PAYS

2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



E ENGINEERING PAYS

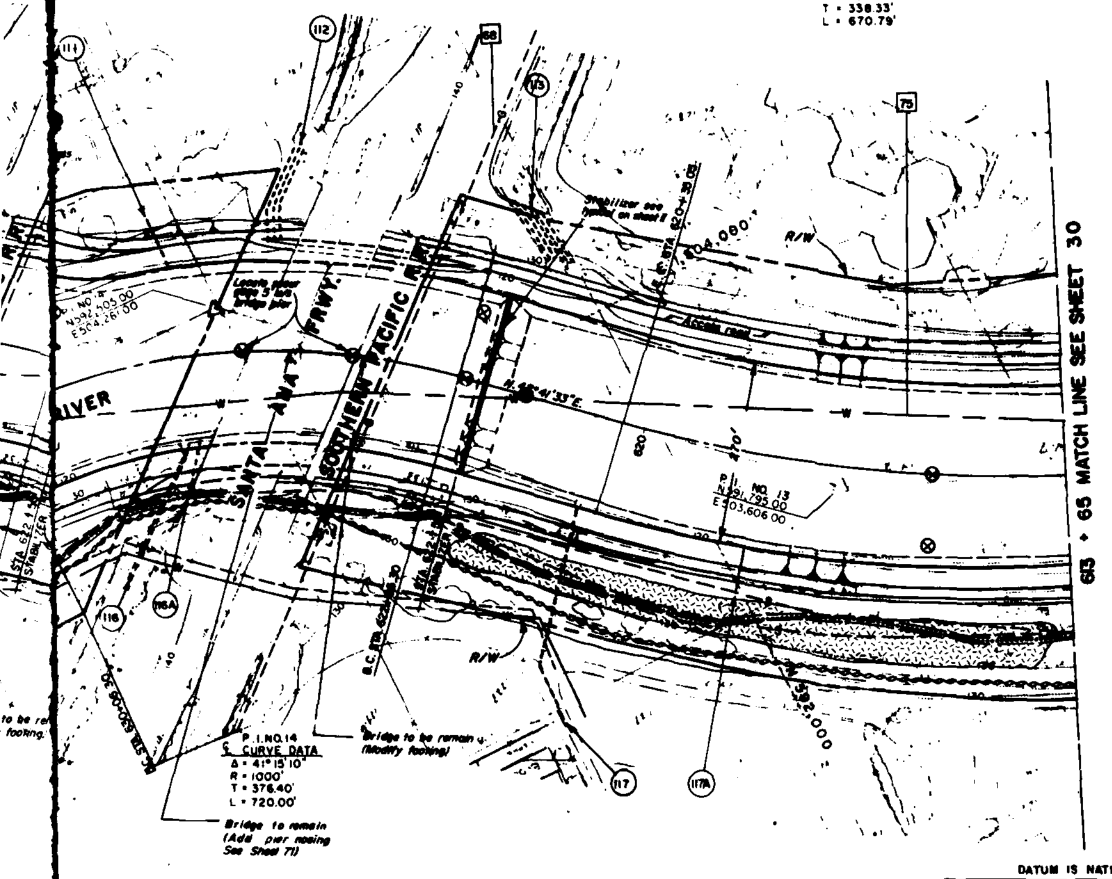


PROFILE

100 200 300 FEET

10 20 30 FEET

P.I. NO. 13
℄ CURVE DATA
Δ = 18°28'39"
R = 2,080'
T = 338.33'
L = 670.79'



P.I. NO. 14
℄ CURVE DATA
Δ = 41° 15' 10"
R = 1000'
T = 376.40'
L = 720.00'

Bridge to remain (Add pier nosing See Sheet 71)

Bridge to be remain (Modify footing)

PLAN

100 200 300 FEET

NOTES:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/ 6" FILTER)
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- NO. UTILITY. SEE SHEET 62 FOR TABULATION
- NO. SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL - PROTECT IN PLACE
- DESIGNATED PONDING AREA
- SCOUR GAGE - SEE SHEET 9 FOR DETAIL

HYDRAULIC ELEMENTS

STA.$_1$	TO STA.$_2$	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030 D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
613+65	624+30	270' TRAP	0.001721	42,000	8.9	13.3	10.7	13.3	10.7
624+80	626+00	270' TRAP	0.001721	42,000	9.1	13.3	10.7	14.3	9.9
626+00	630+00	270' TRAP	0.001721	42,000	8.9	14.3	9.9	14.1	10.0
630+00	633+80	270' TRAP	0.001721	41,000	8.9	14.1	10.0	13.9	9.9
633+80	638+80	270' TRAP	0.001721	41,000	8.8	13.9	9.9	14.0	9.8
638+80	644+36	270' TRAP	0.001721	41,000	8.8	14.0	9.8	13.8	10.0

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: F. Ostermann

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 613 + 65 TO STA. 644+36

SUBMITTED BY:

DATE APPROVED:

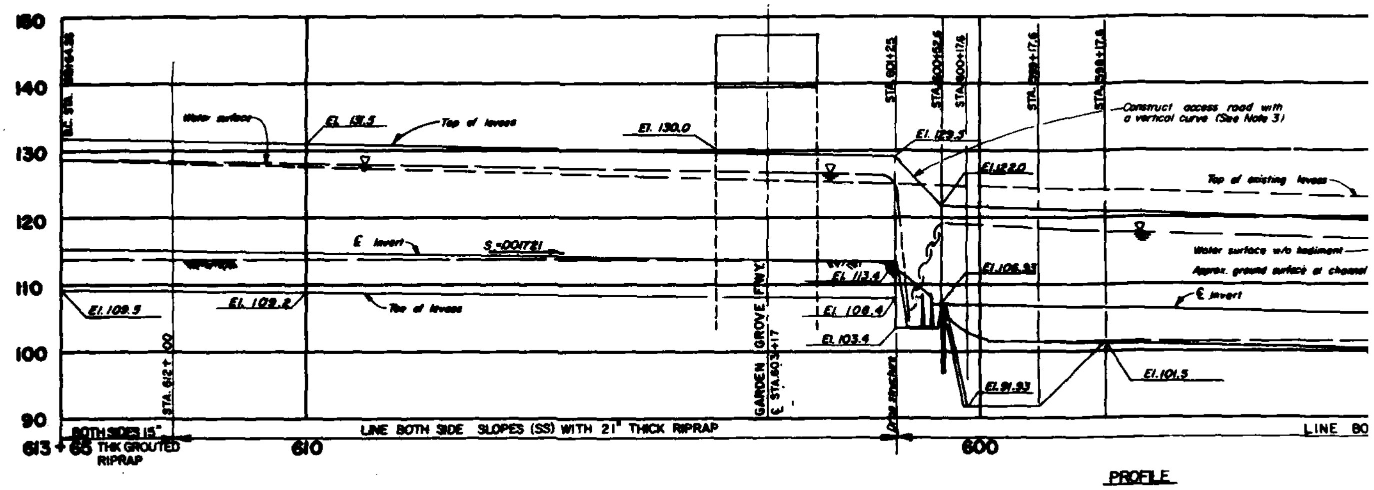
DISTRICT FILE NO.

SHEET 29 OF 105 SHEETS

PLATE 32

SAFETY PAYS

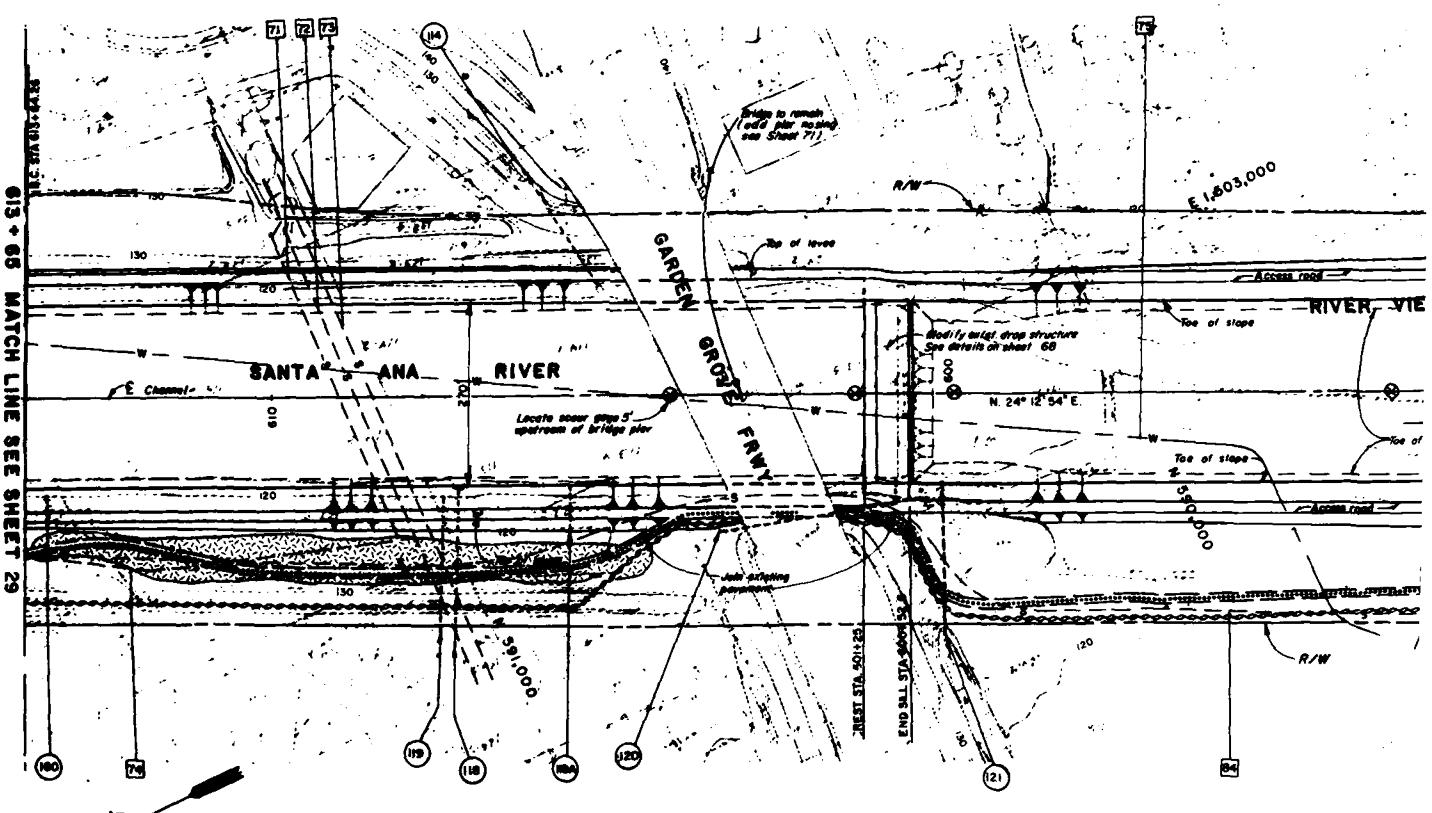
2



PROFILE

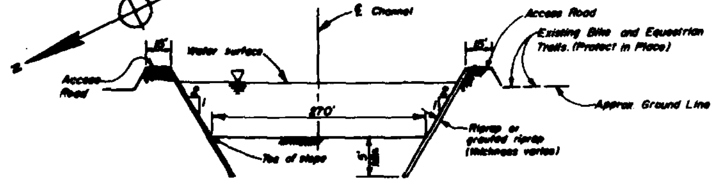
HORIZ. SCALE: 100 0 100 200 300 FEET

VERT. SCALE 10 0 10 20 30 FEET



PLAN

SCALE 100 0 100 200 300 FEET



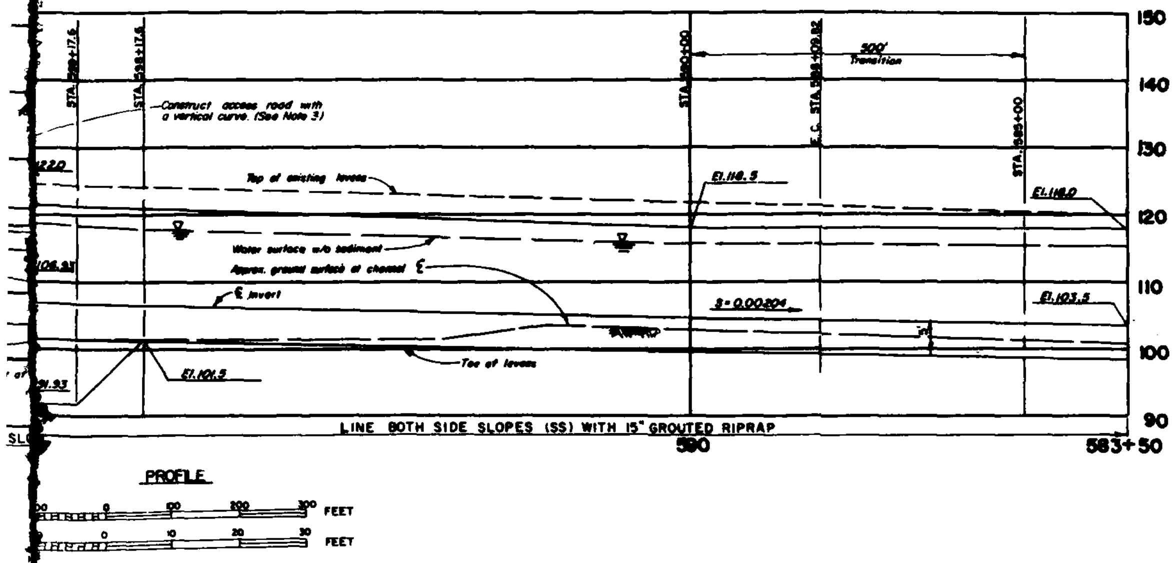
TYPICAL CROSS SECTION
STA.590+00 TO STA.613+65
NOT TO SCALE

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

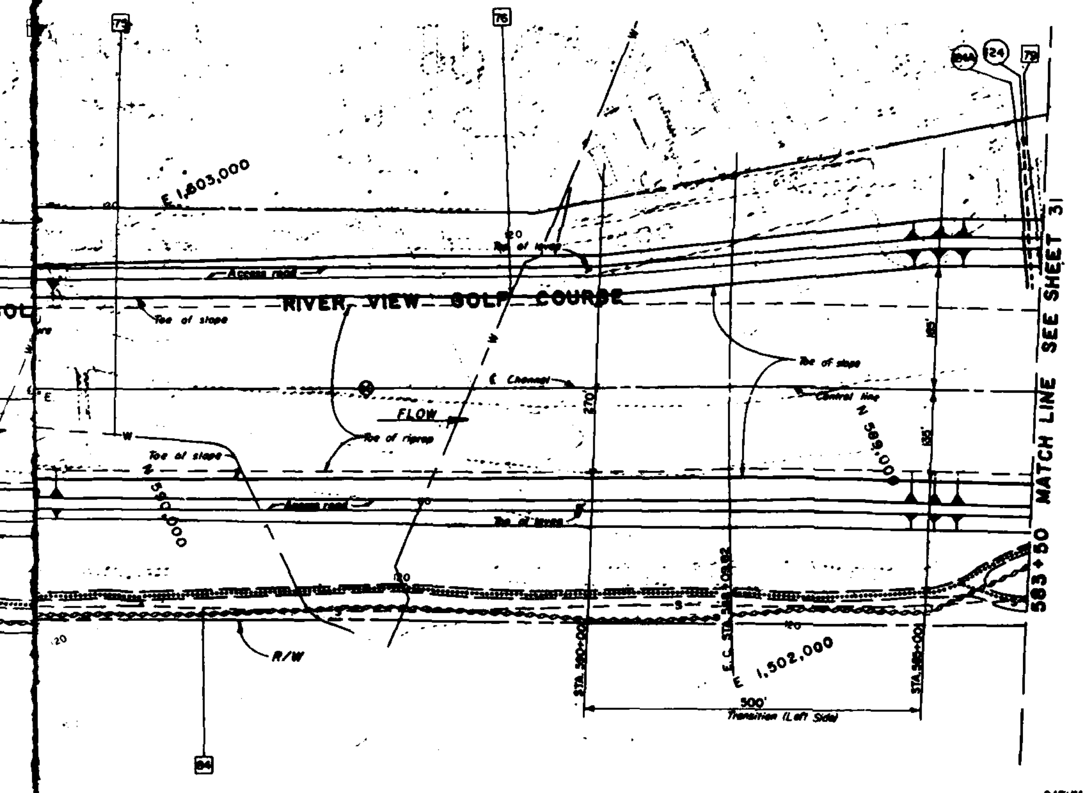
STA., TO STA	
583+50	585+
585+00	600+
600+526	601+
601+25	613+

D_A AND V_A = DI

UE ENGINEERING PAYS



PROFILE



PLAN

LEGEND

- UTILITY. SEE SHEET 62 FOR TABULATION
- SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN / HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL – PROTECT IN PLACE
- DESIGNATED PONDING AREA
- SCOUR GAGE – SEE SHEET 9 FOR DETAIL

NOTES:

1. REMOVE AND REUSE EXISTING SLOPE PROTECTION (18" FACING STONE W/ 6" FILTER).
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS
3. ACCESS ROADS WILL BE CONSTRUCTED WITH A MINIMUM VERTICAL GRADE OF 10% AND A 90-FOOT MINIMUM LENGTH OF ANY VERTICAL CURVE.

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .030 D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
583+50	585+00	360 TRAP	0.00204	42,000	8.0	11.9	10.3	11.8	10.3
585+00	600+82.6	TRANS	0.00204	42,000	VARIES	11.8	10.3	11.1	12.9
							n = .030		
600+82.6	601+25	VARIES	DROP STRUCTURE						
601+25	613+65	270 TRAP	0.00172	42,000	8.9	12.8	11.2	13.3	10.7

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: P. Panenezo
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 583+50 TO STA. 613+65

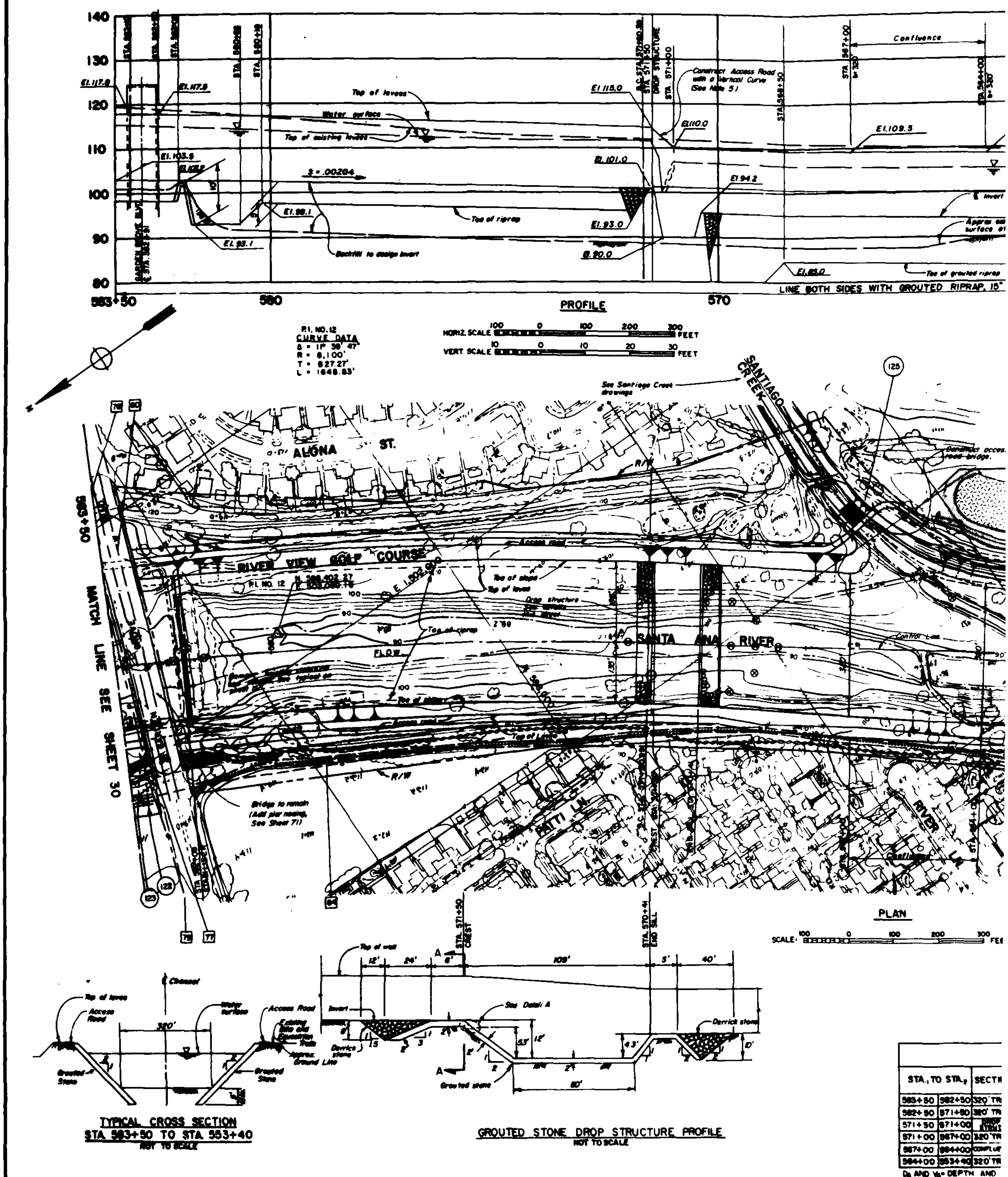
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 30 OF 108 SHEETS

PLATE 33

SAFETY PAYS

1

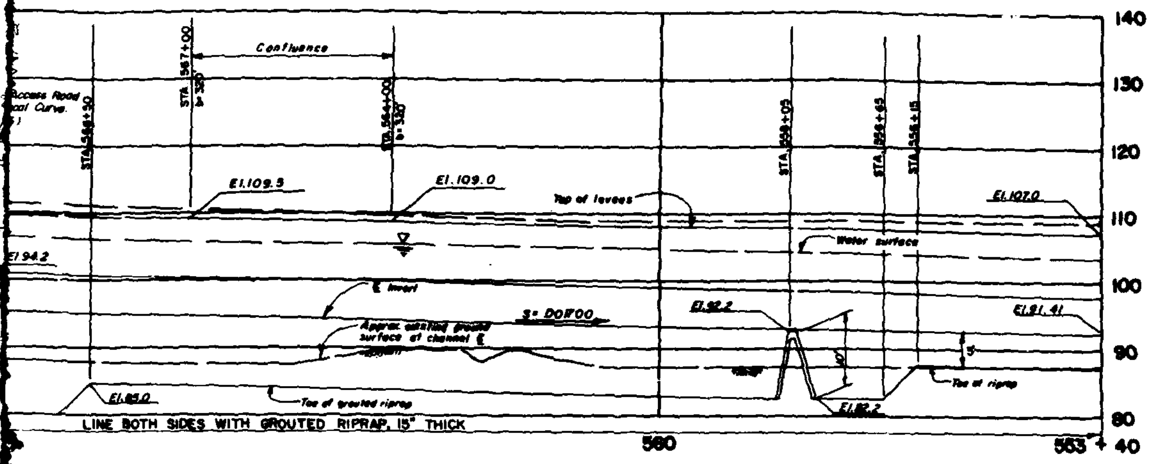
2

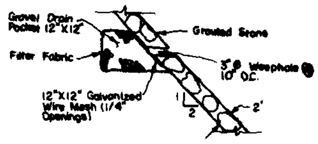


STA.1 TO STA.2	SECTI
583+50	582+50	320' TR
582+50	571+50	320' TR
571+50	571+00	DROP STRUC
571+00	567+00	320' TR
567+00	564+00	CONFLUE
564+00	563+40	320' TR

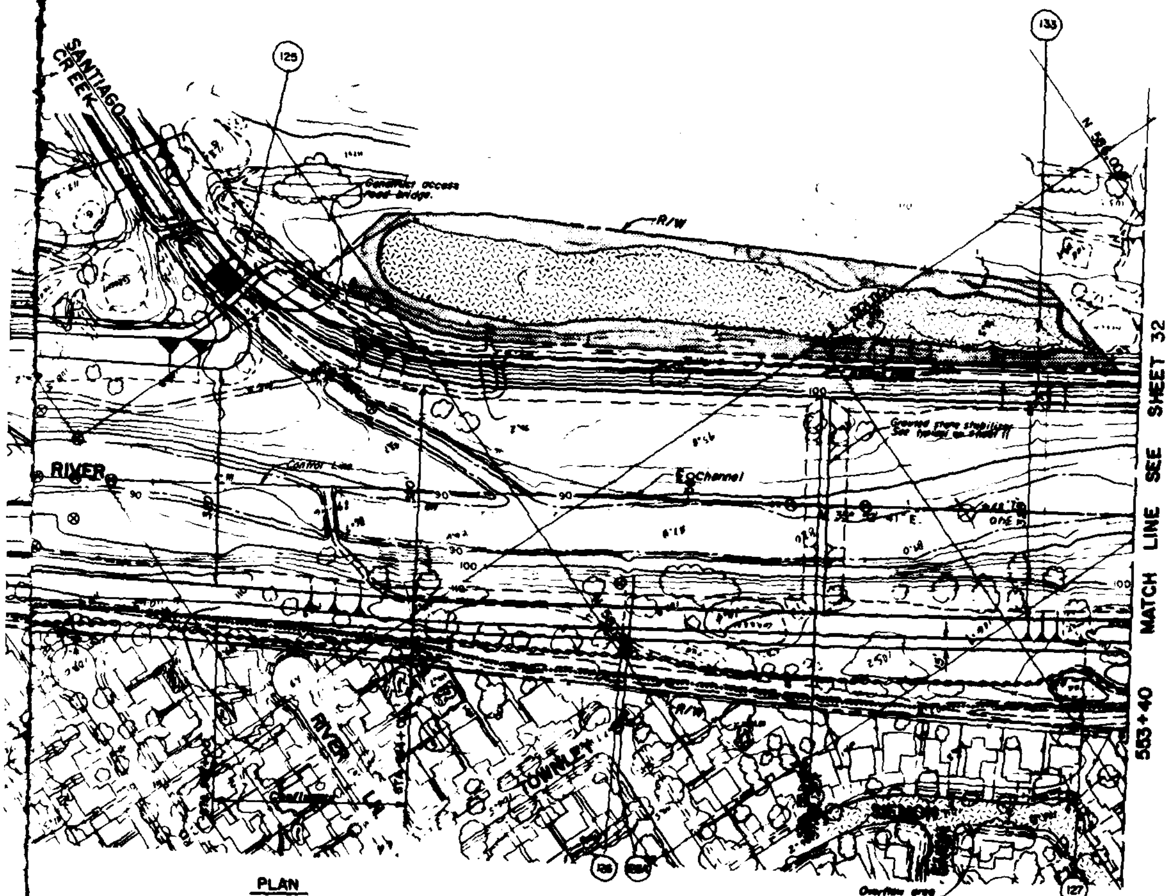
D_s AND V_s = DEPTH AND

LUE ENGINEERING PAYS





DETAIL A
NOT TO SCALE



PLAN

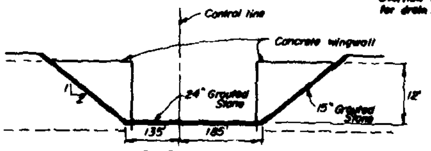
SCALE: 100 0 100 200 300 FEET

LEGEND

- NO UTILITY SEE SHEET 62 FOR TABULATION
- (NO) SIDE DRAIN SEE SHEET 70 FOR DETAILS
- EQUESTRIAN/HIKING TRAIL
- EXISTING BIKE TRAIL—PROTECT IN PLACE
- ⊗ SCOUR GAGE - SEE SHEET 9 FOR DETAIL
- DESIGNATED PONDING AREA
- ADDITIONAL R/W REQUIRED

NOTES:

1. DEPTHS AND VELOCITIES ARE BASED ON CHANNEL CONDITIONS WITH SEDIMENT.
2. "n"value-0.05, USED FOR GOLF COURSE (LEFT OVERBANK)
   "n"value-0.03, USED FOR BOTTOM OF CHANNEL.
3. REMOVE AND REUSE EXISTING SIDE SLOPE PROTECTION FROM RIGHT BANK ONLY (18" FACING STONE WITH 6" FILTER STONE)
4. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A C PAVING DETAILS
5. ACCESS ROADS WILL BE CONSTRUCTED WITH A MINIMUM VERTICAL GRADE OF 10% AND A 90-FOOT MINIMUM LENGTH OF ANY VERTICAL CURVE.



SECTION A-A
NOT TO SCALE

HYDRAULIC ELEMENTS

STA.1 TO STA.2		SECTION	DESIGN INVERT SLOPE	Q (cfs)	Dc (ft)	n = .030			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
583+50	582+50	320' TRAP	0.00204	42000	8.0	11.9	10.3	11.3	10.9
582+50	571+50	320' TRAP	0.00204	42000	8.0	11.3	10.9	11.0	11.1
571+50	571+00	[illegible]		42000	VARIES	12.8	11.2	12.4	9.8
571+00	567+00	320' TRAP	0.001700	42000	8.0	12.4	9.8	12.5	9.7
567+00	564+00	CONFLUENCE	0.001700	VARIES	VARIES	12.5	9.7	12.5	10.7
564+00	553+40	320' TRAP	0.001700	46000	8.5	12.5	10.7	12.2	10.9

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:
CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 553+40 TO STA. 583+50

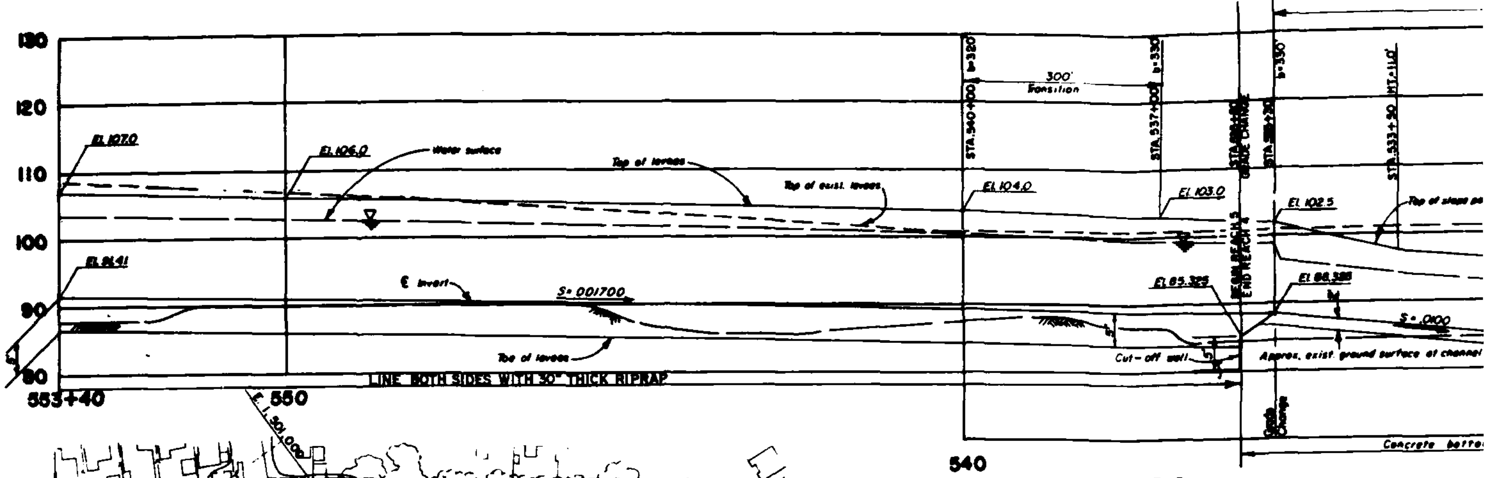
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

SHEET 31 OF 109 SHEETS

PLATE 34

SAFETY PAYS

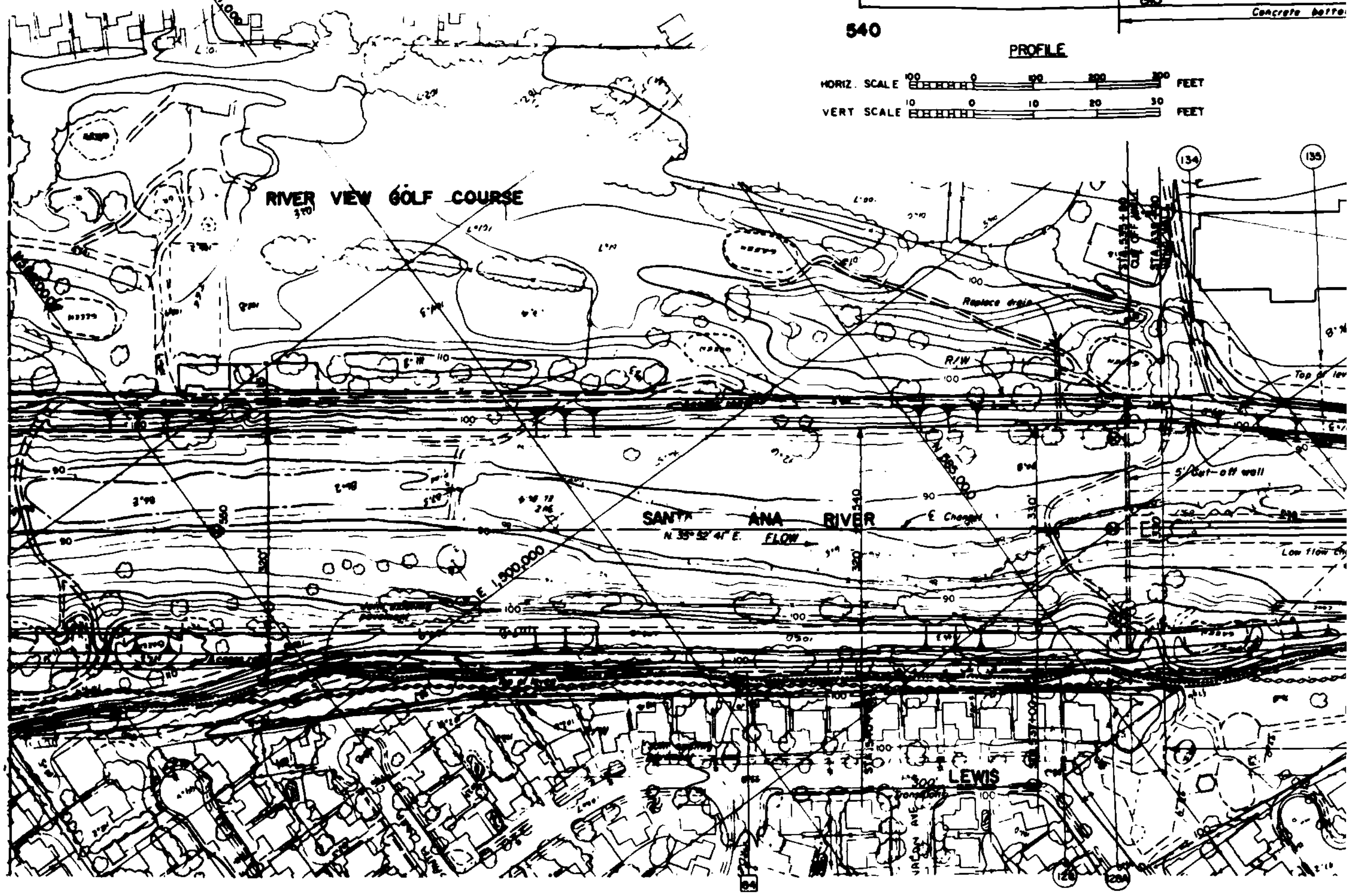
VALUE ENGINEERING PAY



PROFILE

HORIZ. SCALE 100 0 100 200 300 FEET

VERT SCALE 10 0 10 20 30 FEET

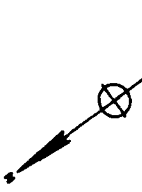


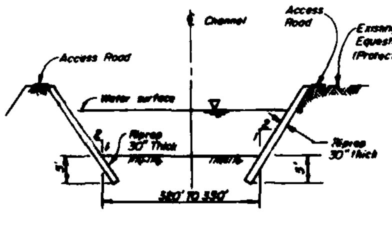
553+40 MATCH LINE SEE SHEET 31

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

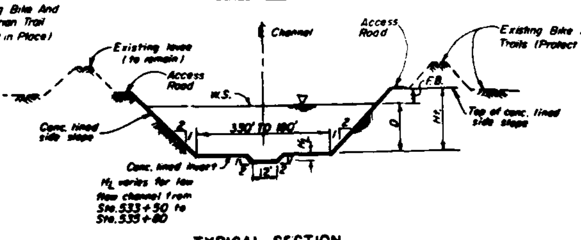
PLAN

SCALE 100 0 100 200 300 FEET





TYPICAL CROSS SECTION
STA. 553+40 TO STA. 535+80
NOT TO SCALE



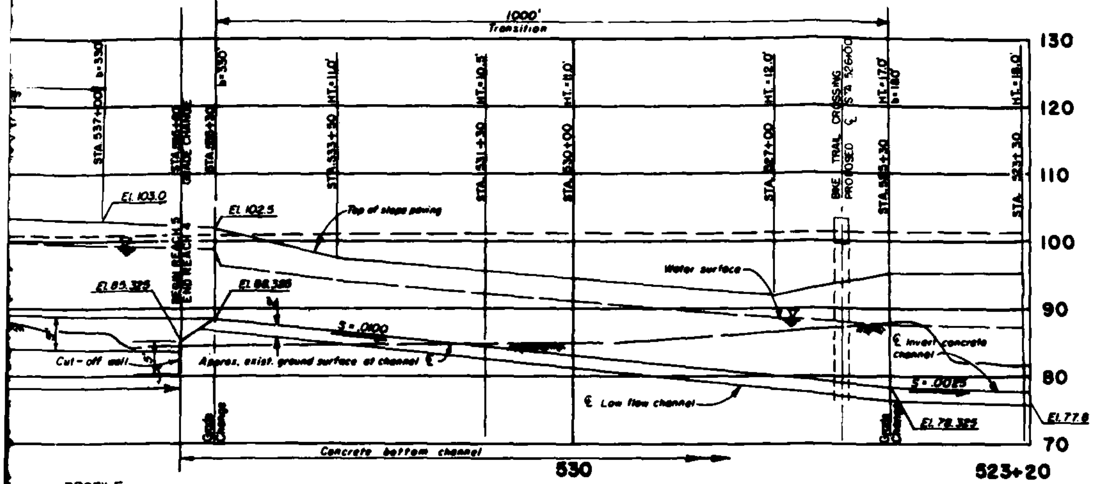
TYPICAL SECTION
STA. 535+80 TO STA. 523+20
NOT TO SCALE

STA.₁ TO STA.₂		SECTION	DE S
553+40	550+00	320' TRAP	0.
550+00	540+00	320' TRAP	0.
540+00	537+00	TRANSITION	0.
537+00	535+80	330' TRAP	0.
535+80	535+30	330' TRAP	0.
535+30	525+30	[illegible]	0.
525+30	523+30	[illegible]	0.

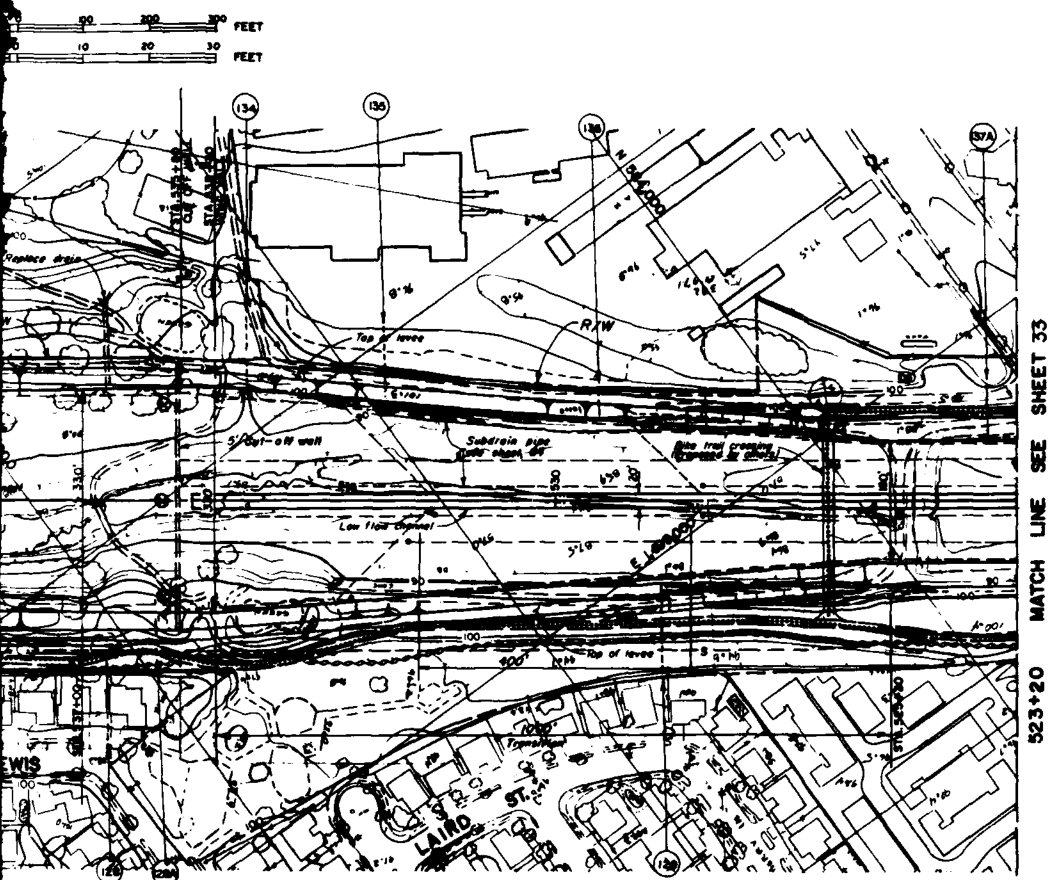
D_A AND V_A = DEPTH AND VELOCIT

SAFETY PAYS

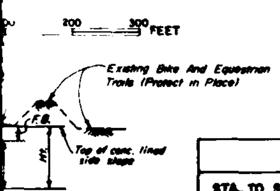
...UE ENGINEERING PAYS

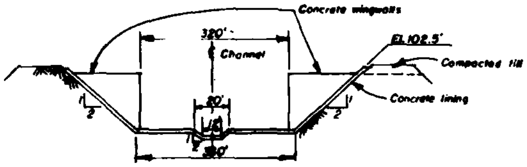


PROFILE



...AN





SECTION AT STA. 535+30
NOT TO SCALE

HYDRAULIC ELEMENTS

STA.₁	TO STA.₂	SECTION	DESIGN SLOPE		Q (cfs)	Dc (ft)	D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}	n
553+40	550+00	320' TRAP	0.001700		46,000	8.5	12.2	10.9	12.1	11.1	.03
550+00	540+00	320' TRAP	0.001700		46,000	8.6	12.1	11.1	11.3	11.9	.03
540+00	537+00	TRANSITION	0.001700		46,000	VARIES	11.3	11.9	11.0	11.8	.03
537+00	535+80	330' TRAP	0.001700		46,000	8.3	11.0	11.8	10.8	12.1	.03
535+80	535+30	330' TRAP	0.001700		46,000	8.3	10.8	12.1	10.7	12.2	.03
535+30	525+30	[illegible]	0.0100		46,000	VARIES	10.7	12.2	9.1	24.8	.014
525+30	523+30	[illegible]	0.00250		46,000	12.1	9.1	24.8	9.3	24.5	.014

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

LEGEND

- UTILITY SEE SHEET 62 FOR TABULATION
- SIDE DRAIN SEE SHEET 70 FOR DETAILS
- EQUESTRIAN / HIKING TRAIL
- NEW BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- SCOUR GAGE - SEE SHEET 9 FOR DETAIL

NOTES

1. FROM STA. 553+40 TO STA. 535+30 DEPTHS AND VELOCITIES ARE BASED ON CHANNEL CONDITIONS WITH SEDIMENT.
2. "n" VALUE 0.05 USED FOR GOLF COURSE (LEFT OVERBANK) "n" VALUE 0.03 USED FOR BOTTOM OF CHANNEL.
3. REMOVE AND REUSE EXISTING SIDE SLOPE PROTECTION (EAST LEVEE, 18" ROCK).
4. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:
DRAWN BY: DRV
CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 523+20 TO STA. 553+40

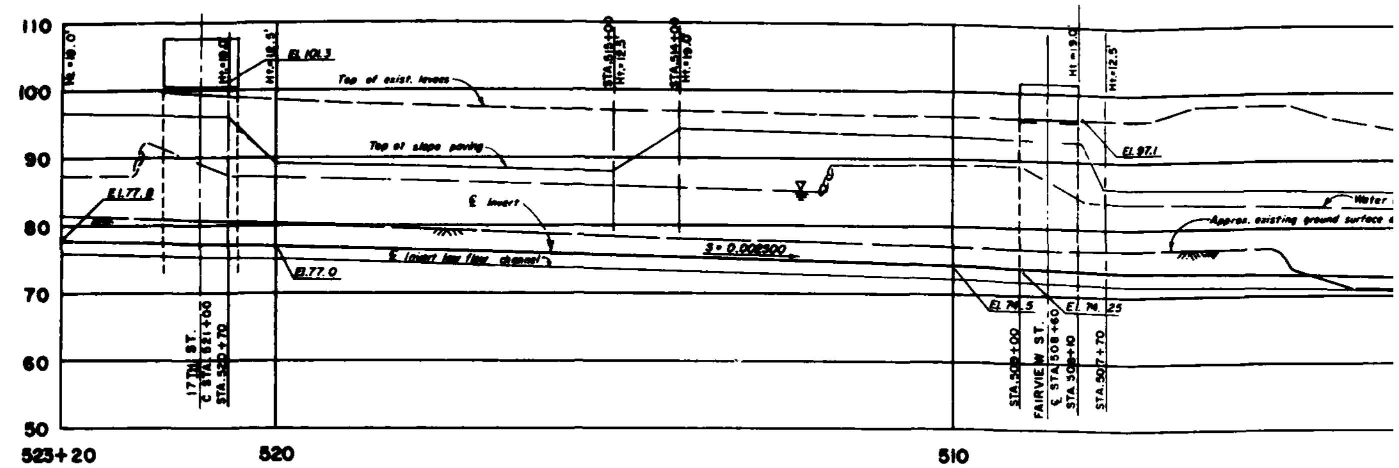
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 38 OF 108 SHEETS

PLATE 36

SAFETY PAYS

2

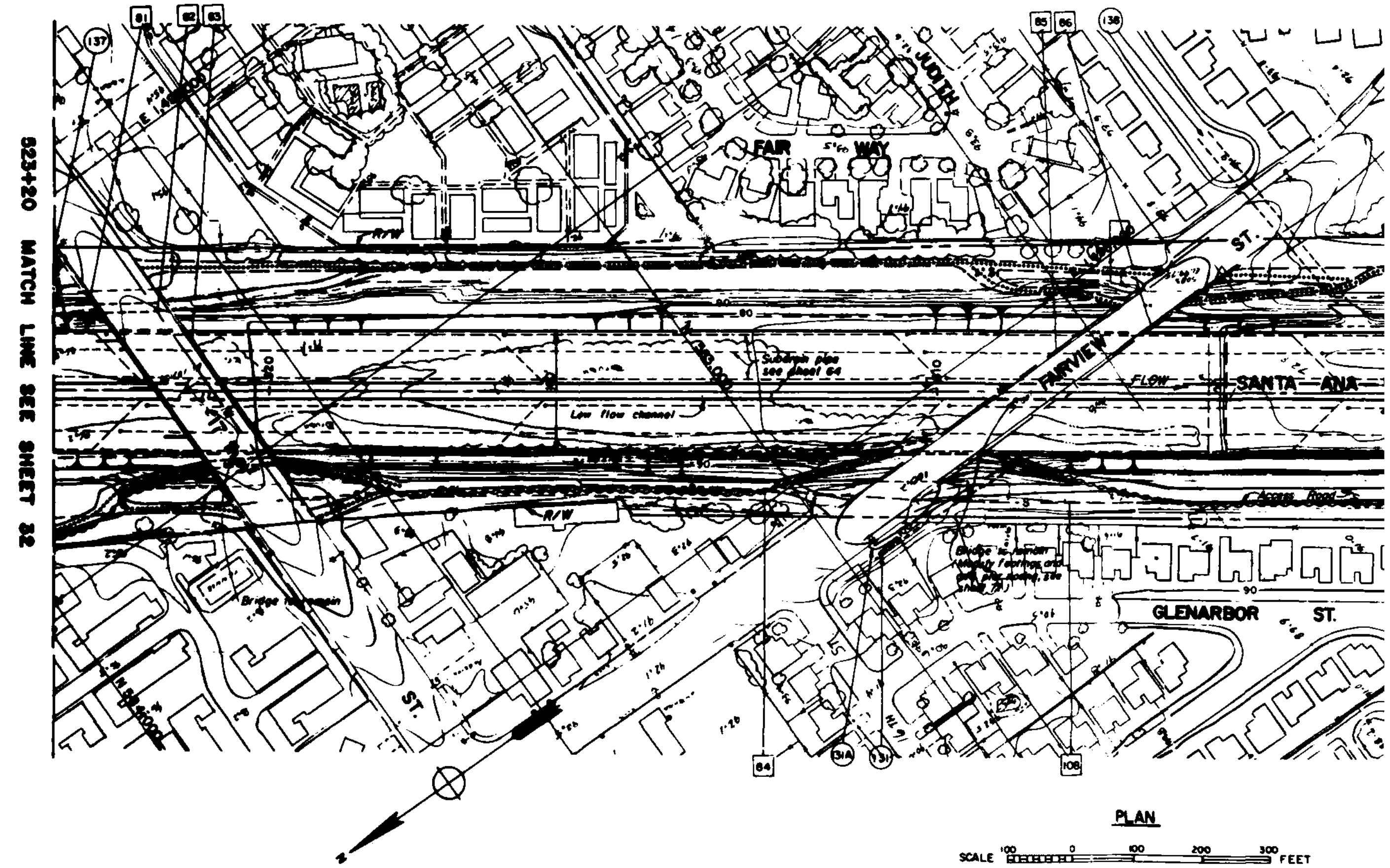
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



PROFILE

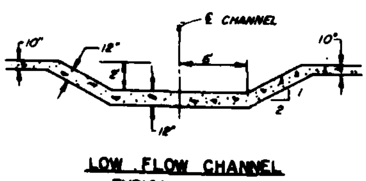
HORIZ SCALE: 100 0 100 200 300 FEET

VERT SCALE: 10 0 10 20 30 FEET

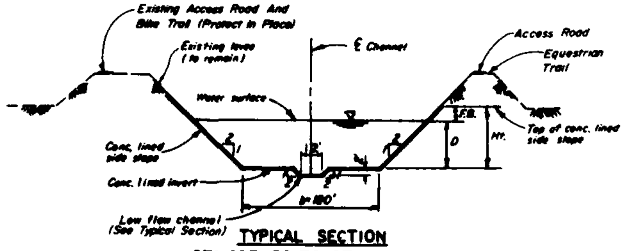


PLAN

SCALE 100 0 100 200 300 FEET



LOW FLOW CHANNEL TYPICAL SECTION NOT TO SCALE

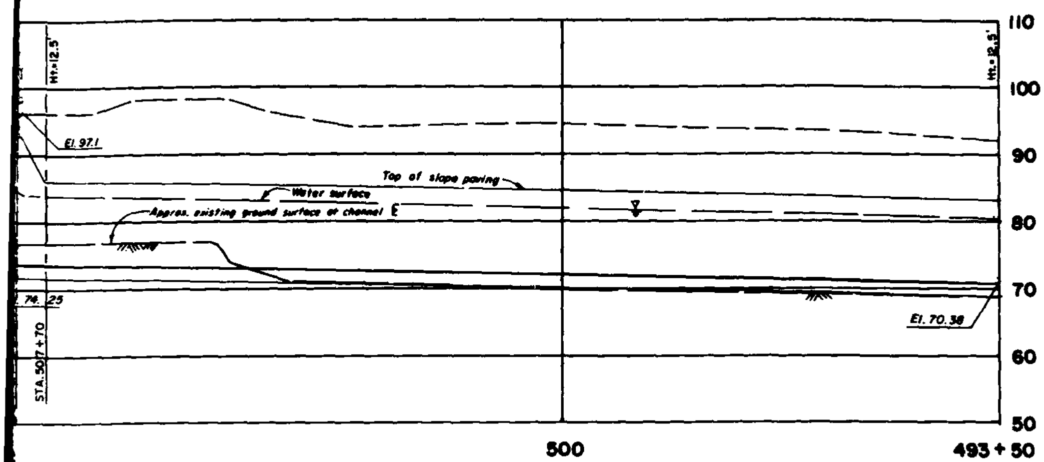


TYPICAL SECTION STA. 493+50 TO STA. 523+20 NOT TO SCALE

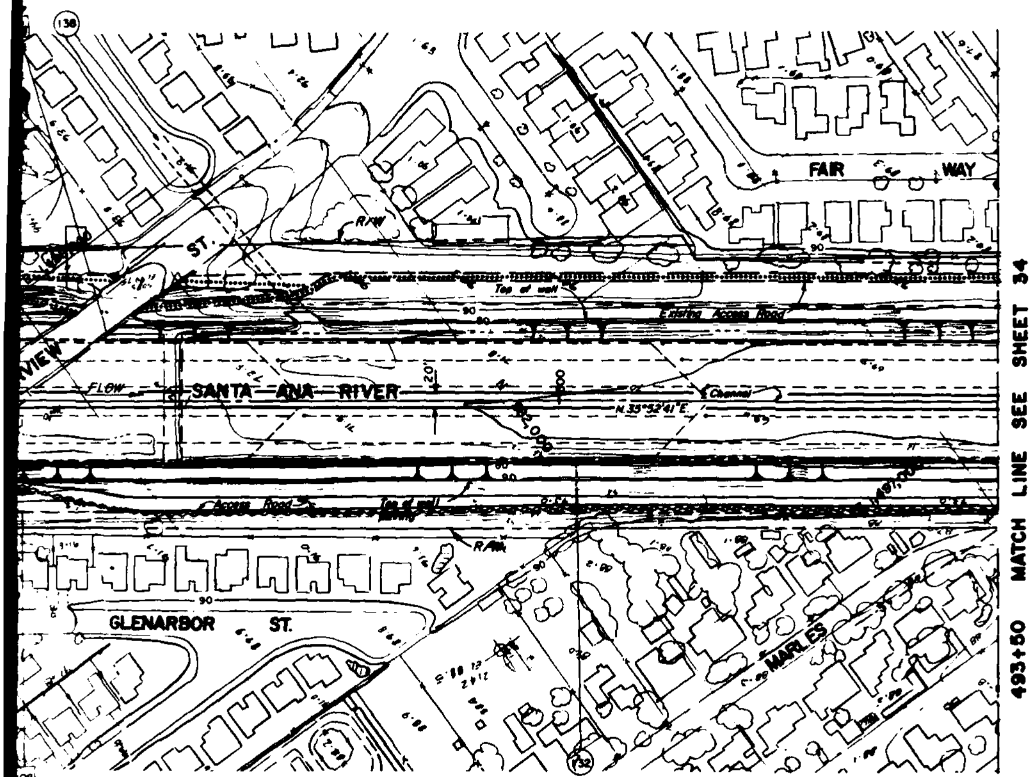
STA.1 TO	STA.2	S…
523+40	523+30	T…
523+20	521+90	T…
521+90	520+70	T…
520+70	510+35	T…
510+35	508+10	T…
508+10	493+50	T…

D_A AND V_A=DEPTH AND…

JE ENGINEERING PAYS



PROFILE



NOTE:

1. REMOVE EXISTING 4" TO 8" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- NO — UTILITY. SEE SHEET 62 FOR TABULATION.
- (NO) — SIDE DRAIN SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN / HIKING TRAIL.
- NEW ACCESS ROAD AND BIKE TRAIL.
- EXISTING ACCESS ROAD AND BIKE TRAIL - PROTECT IN PLACE

PLAN

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n=.014 D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
523+40	523+30	TRAP. b=180'	.002500	46000	11.9	9.5	24.4	9.5	24.4
523+20	521+90	TRAP. b=180'	.002500	46000	11.9	9.3	24.5	9.3	24.3
521+90	520+70	TRAP. b=180'	.002500	46000	11.9	14.9	14.8	10.0	22.6
520+70	510+35	TRAP. b=180'	.002500	46000	11.9	10.0	22.6	9.9	22.7
510+35	508+10	TRAP. b=180'	.002500	46000	11.9	14.3	15.2	10.0	22.6
508+10	493+50	TRAP. b=180'	.002500	46000	11.9	10.0	22.6	9.9	22.7

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: AYKPPU

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 493+50 TO STA. 523+20

CHECKED BY:

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

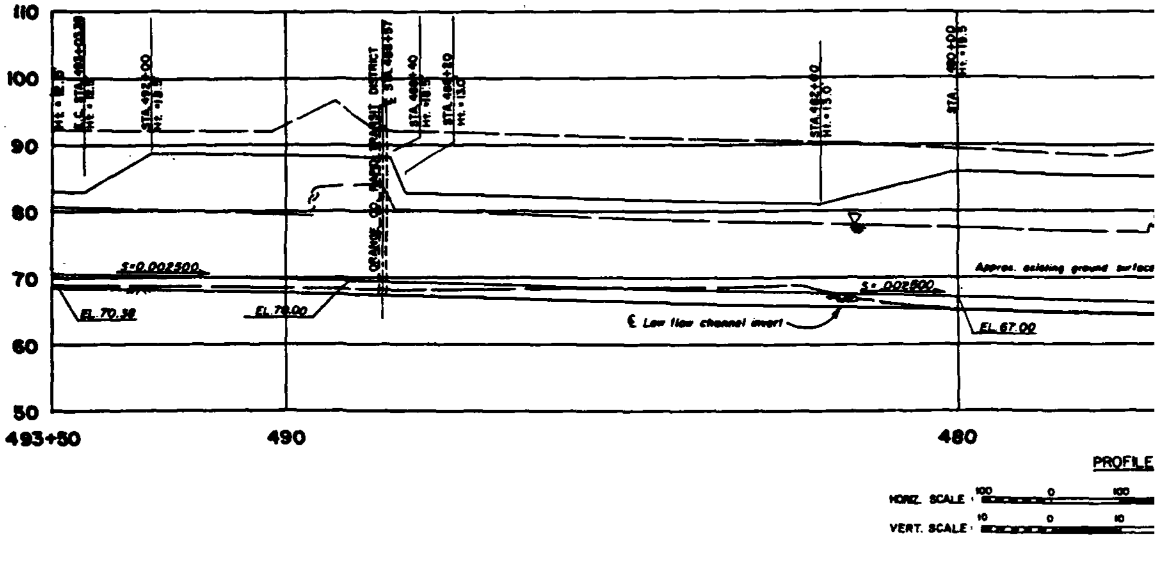
SHEET 33 OF 108 SHEETS

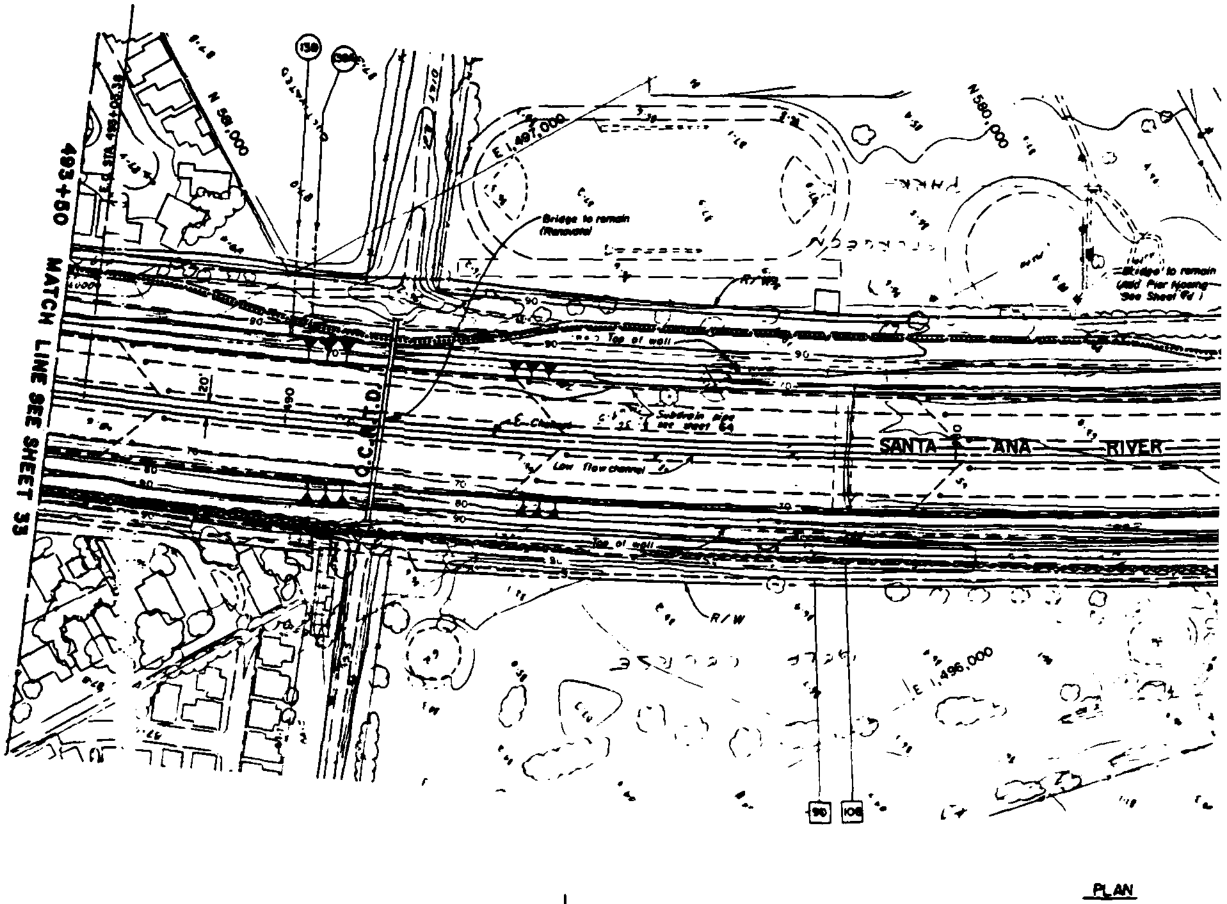
PLATE 36

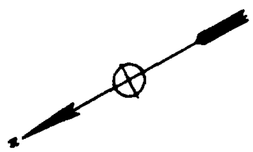
SAFETY PAYS

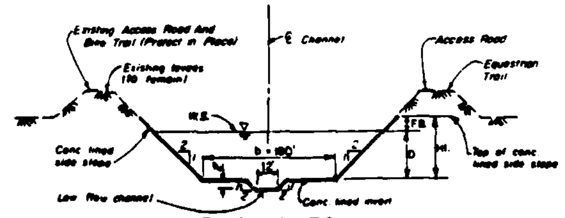
2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING







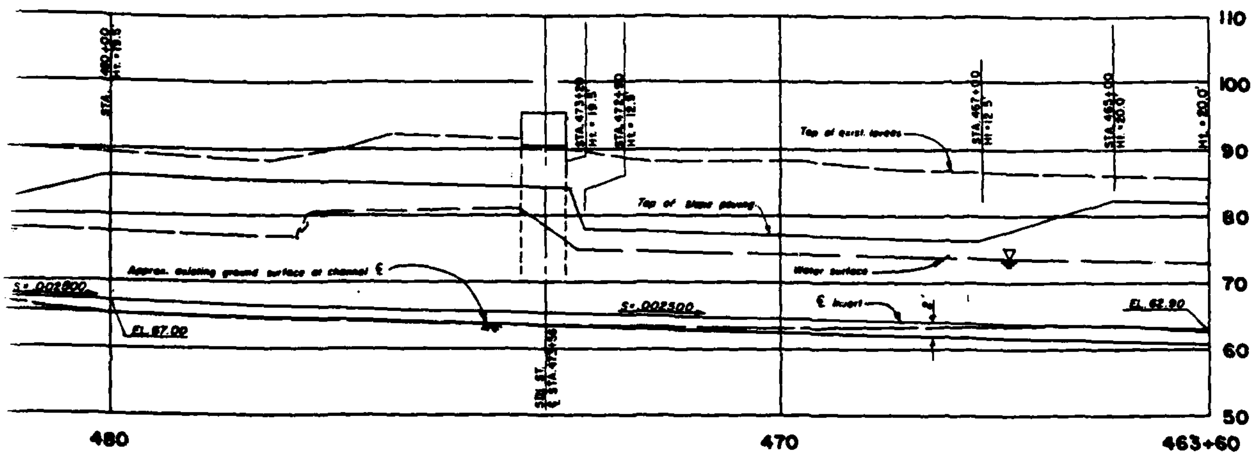


TYPICAL SECTION

STA 463+60 TO STA. 493+50

NOT TO SCALE

1 of 3



PROFILE

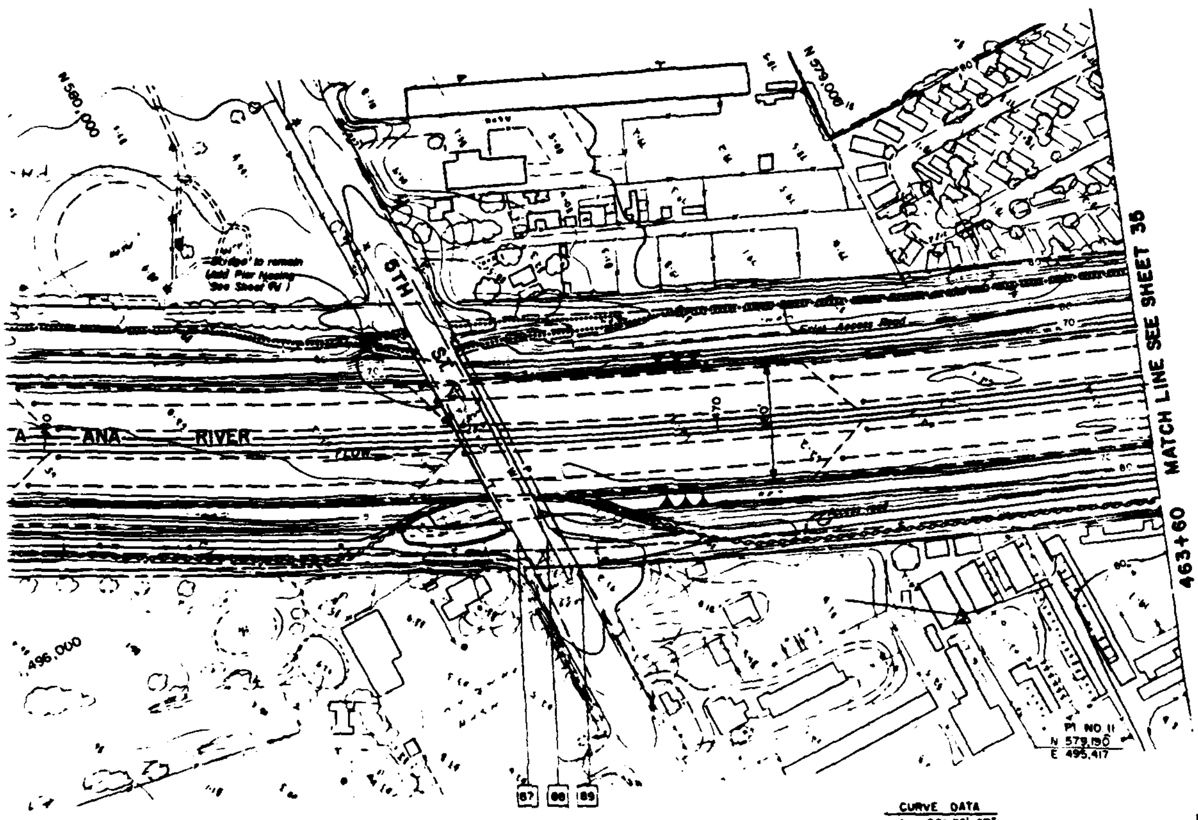
HORIZ. SCALE: 100 0 100 200 300 FEET

VERT. SCALE: 10 0 10 20 30 FEET

P.I. NO. 11

℄ CURVE DATA

Δ = 26° 30' 07"
R = 11,400'
T = 2,684.55'
L = 5,273.03'



NOTES:

1. REMOVE EXISTING 4"-8" FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPIC A.C PAVING DETAILS.

LEGEND

NO. UTILITY SEE SHEE

NO. SIDE DRAIN. SEE SH

EQUESTRIAN / HIKIN

EXISTING ACCESS R PROTECT IN PLACE.

CURVE DATA

Δ = 26° 30' 07"
R = 11,400'
T = 2,684.55'
L = 5,273.03'

PLAN

SCALE 100 0 100 200 300 FEET

HYDRAULIC ELEMENTS									
STA. TO STA.$_2$		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						D_A	V_{A_1}	D_{A_2}	V_{A_2}
493+50	489+50	[illegible]	.002500	46,000	11.9	9.9	22.7	9.9	22.7
489+80	488+57	[illegible]	.002500	46,000	11.9	14.3	15.2	10.2	22.1
488+57	477+00	[illegible]	.002500	46,000	11.9	10.2	22.1	9.9	22.7
477+00	473+20	[illegible]	.002500	46,000	11.9	14.3	15.2	9.8	23.2
473+20	463+60	[illegible]	.002500	46,000	11.9	9.8	23.2	9.8	23.0

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL D

SYMBOL	DESCRIPTIONS
REVISIONS	

U. S. ARMY
LO
CORPS

DESIGNED BY.

SANTA ANA RIVER MAINSTEM,
PHASE II GENERAL DESIGN ME

DRAWN BY.
F CASTELLANO
D.VILPPU

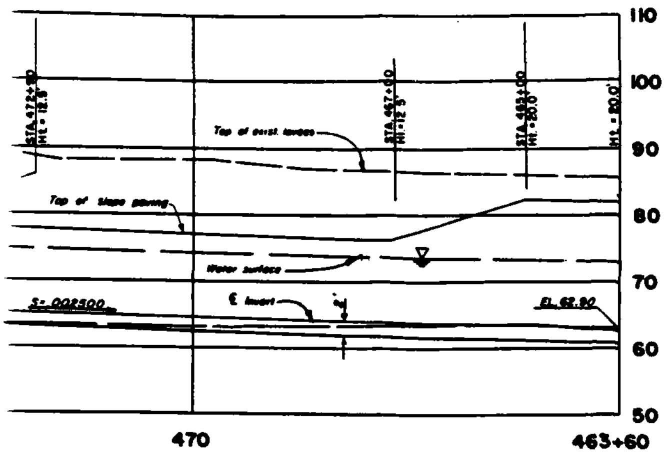
CHECKED BY.

LOWER SANTA ANA RIV
PLAN AND PROF
STA. 463+60 TO STA.

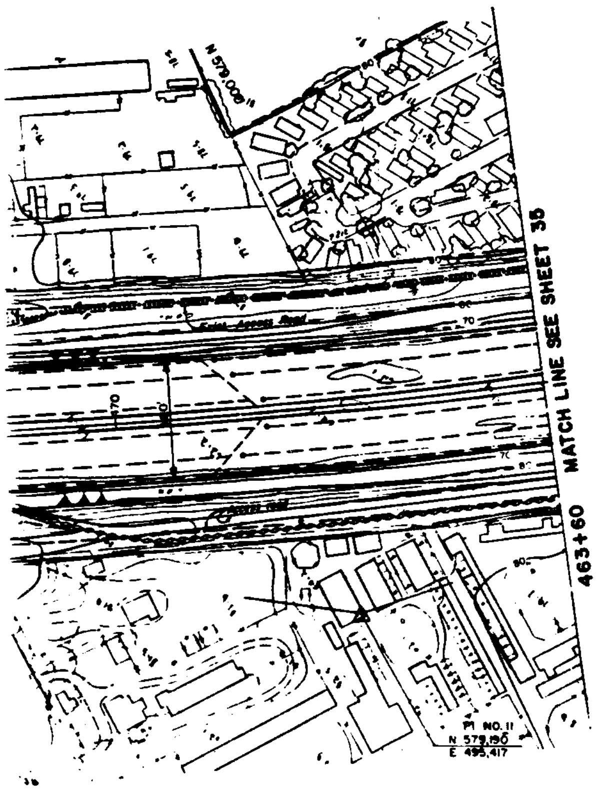
SUBMITTED BY.

DATE APPROVED.

DISTRICT FILE NO.



P.I. NO. 11
℄ CURVE DATA
Δ = 26° 30' 07"
R = 11,400'
T = 2,684.55'
L = 5,273.03'



NOTES:

1. REMOVE EXISTING 4"-8" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- NO — UTILITY - SEE SHEET 62 FOR TABULATION
- NO (circle) — SIDE DRAIN. SEE SHEET 70 FOR DETAILS
- EQUESTRIAN / HIKING TRAIL
- EXISTING ACCESS ROAD AND BIKE TRAIL - PROTECT IN PLACE.

CURVE DATA
Δ = 26° 30' 07"
R = 11,400'
T = 2,684.55'
L = 5,273.03'

HYDRAULIC ELEMENTS

DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
			D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
.002500	46,000	11.9	9.9	22.7	9.9	22.7
.002500	46,000	11.9	14.3	15.2	10.2	22.1
.002500	46,000	11.9	10.2	22.1	9.9	22.7
.002500	46,000	11.9	14.3	15.2	9.6	23.2
.002500	46,000	11.9	9.8	23.2	9.8	23.0

VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: F CASTELLANO, D.VILPPU

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 463+60 TO STA. 493+50

SUBMITTED BY:

DATE APPROVED:

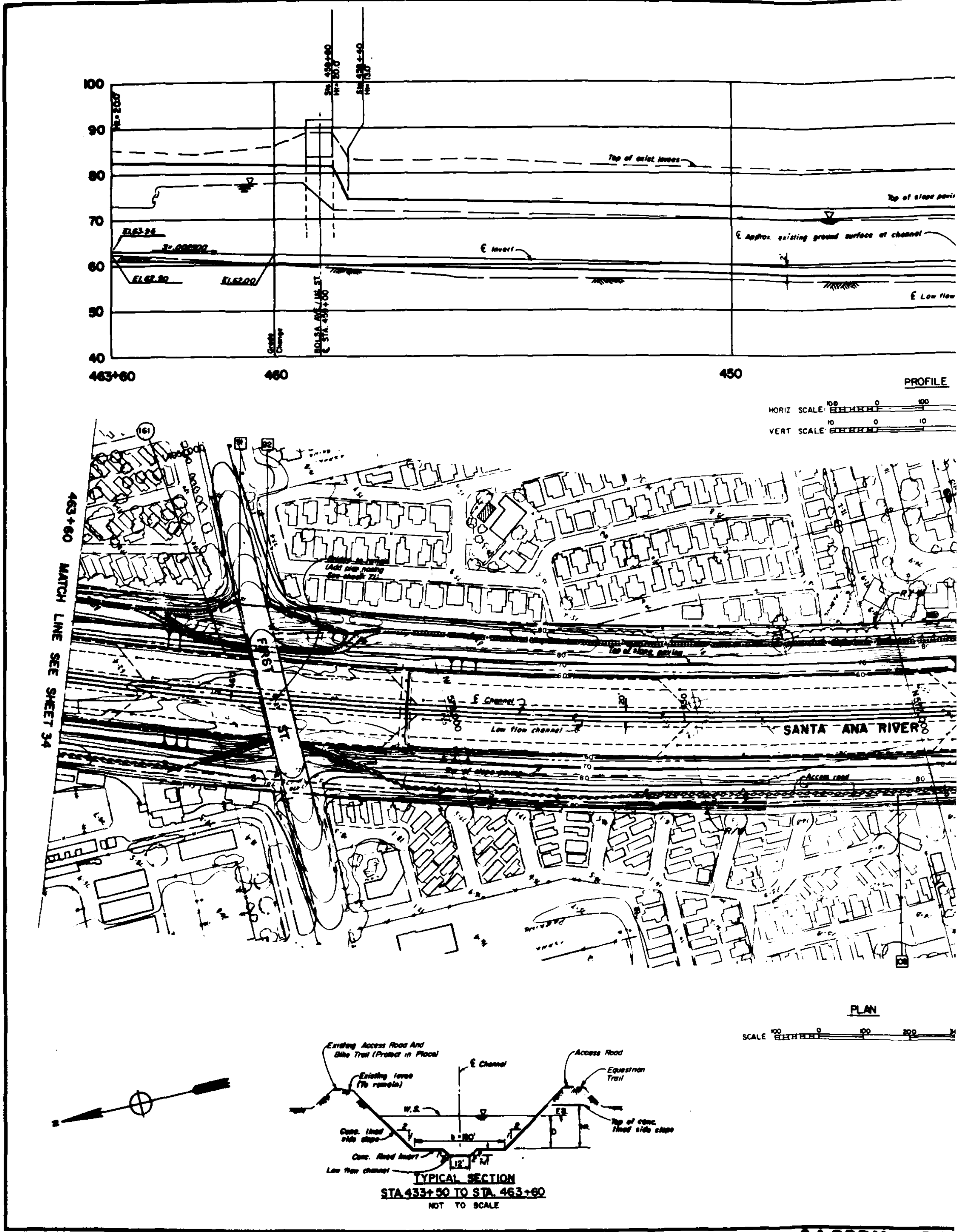
DISTRICT FILE NO.

SHEET 34 OF 105 SHEETS

PLATE 37

383

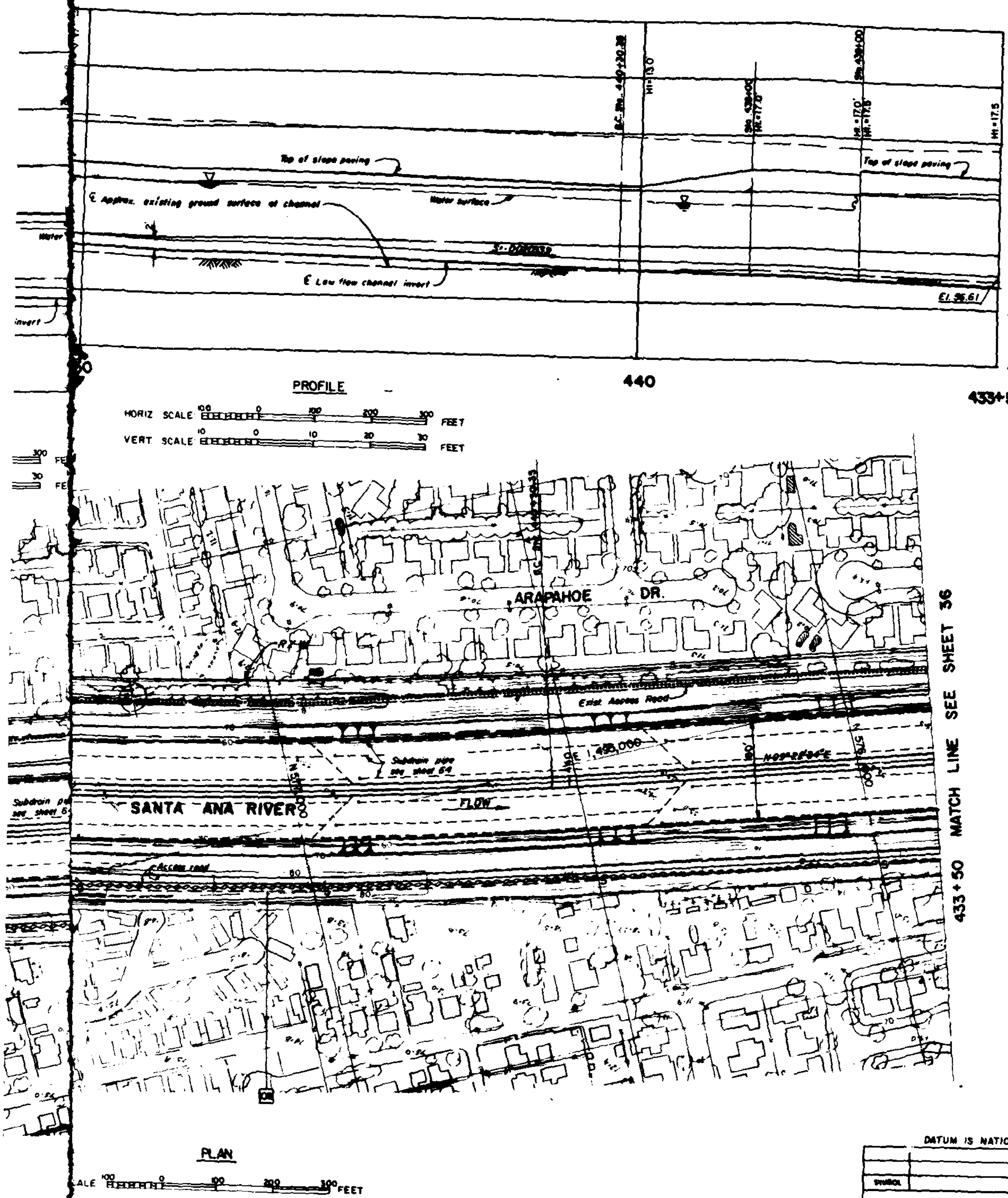
VALUE ENGINEERIN



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY PA

VALUE ENGINEERING PAYS



NOTES:

1. REMOVE EXISTING 4" TO 8" REINFORCED CONCRETE FROM SIDE SLOPES
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

(NO) UTILITY, SEE SHEET 62 FOR TABULATION.

(NO.) SIDE DRAIN, SEE SHEET 70 FOR DETAILS.

EQUESTRIAN / HIKING TRAIL

NEW ACCESS ROAD AND BIKE TRAIL

EXISTING ACCESS ROAD AND BIKE TRAIL-PROTECT IN PLACE

HYDRAULIC ELEMENTS

STA.₁	TO STA.₂	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
463+60	462+50	TRAP b = 180'	.002800	46,000	11.9	9.8	23.0	9.8	23.0
462+50	460+00	TRAP b = 180'	.002800	46,000	11.9	14.4	15.1	15.4	14.1
460+00	456+70	TRAP b = 180'	.0020338	46,000	11.9	15.4	14.1	9.8	23.0
456+70	436+00	TRAP b = 180'	.0020338	46,000	11.9	9.8	23.0	10.5	21.9
436+00	433+50	TRAP b = 180'	.0020338	46,000	11.9	13.7	15.9	14.5	16.0

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 433+50 TO STA. 463+60

SUBMITTED BY:

DATE APPROVED:

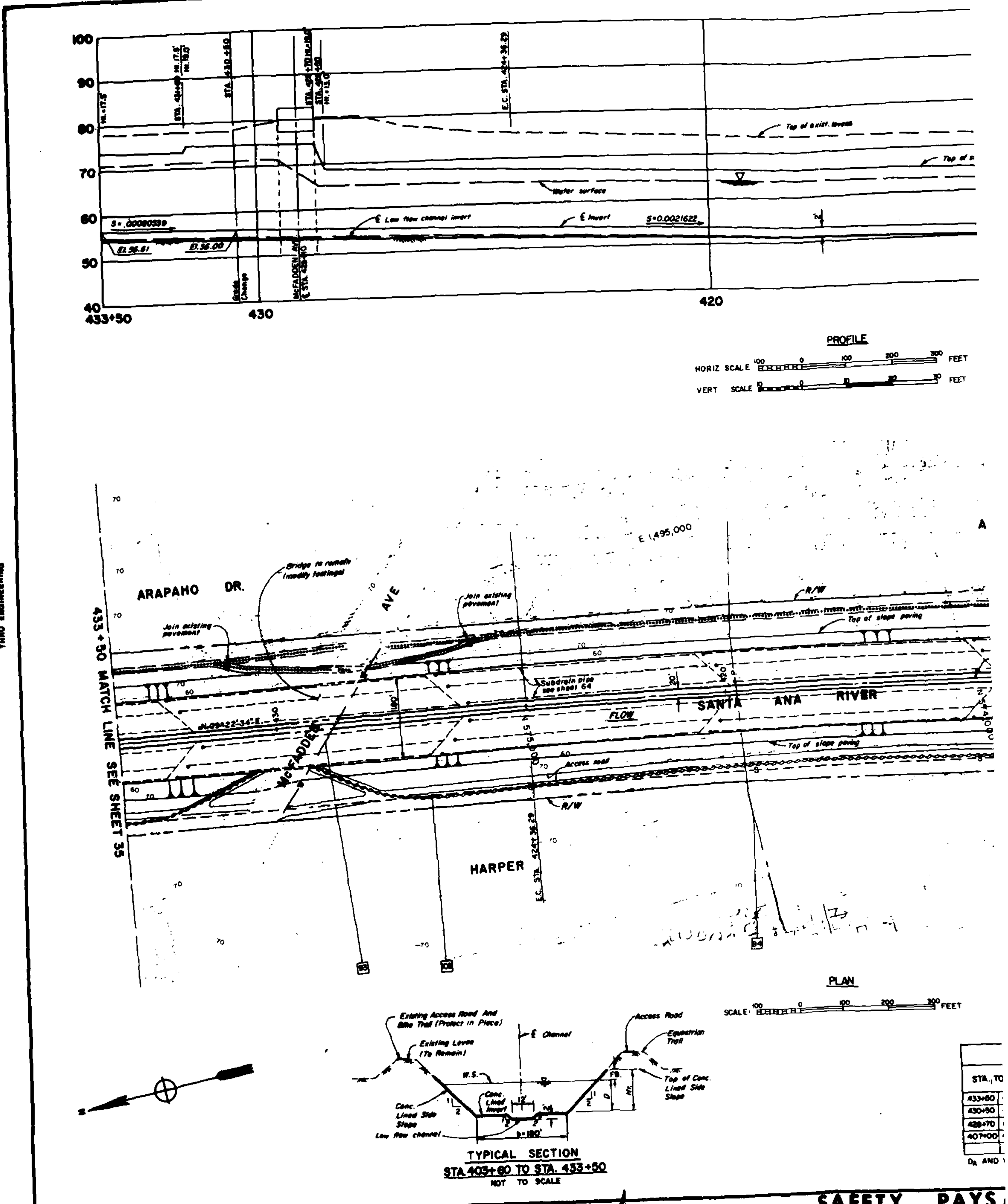
DISTRICT FILE NO.

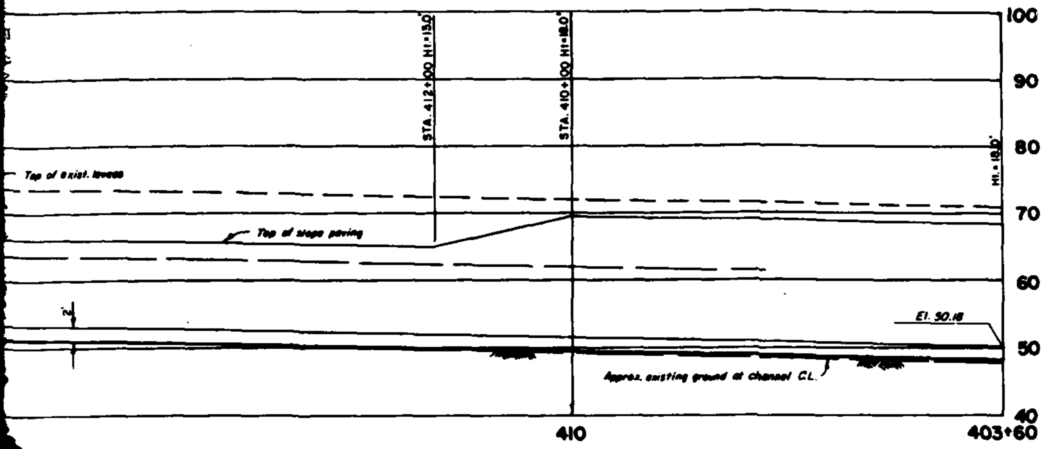
SHEET 35 OF 109 SHEETS

PLATE 36

SAFETY PAYS

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



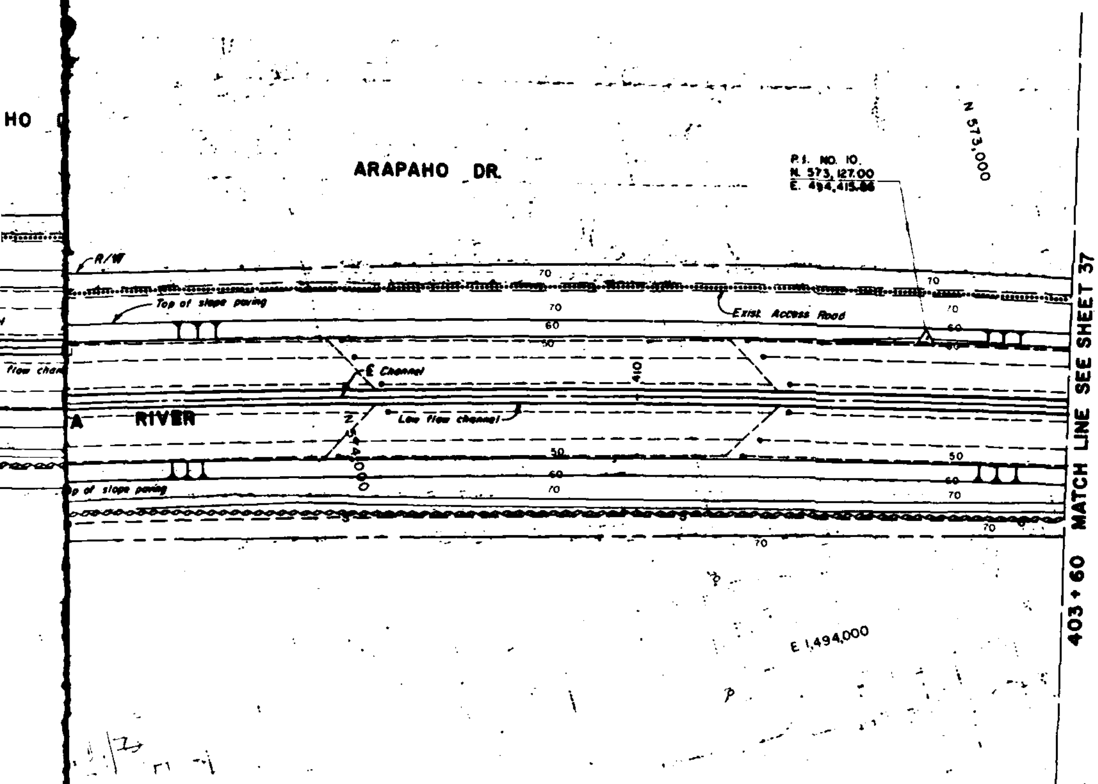


PROFILE

0 100 200 300 FEET

0 10 20 30 FEET

P.I. NO. 10
℄ CURVE DATA
Δ = 10° 39' 48"
R = 20,000'
T = 1866.49'
L = 3,722.20'



NOTE:

1. REMOVE EXISTING 4" TOB" REINFORCED CONCRETE FROM SIDE SLOPES
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL.
- EXISTING ACCES ROAD AND BIKE TRAIL-PROTECT IN PLACE.
- [NO] UTILITY. SEE SHEET 62 FOR TABULATION.

PLAN

100 200 300 FEET

HYDRAULIC ELEMENTS

$STA._1$	TO $STA._2$	SECTION	DESIGN SLOPE	Q (cfs)	D_c (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
433+60	430+30	TRAP. [illegible]	.0020839	46000	11.9	14.5	15.0	15.4	14.1
430+60	428+70	[illegible]	.0021622	46000	11.9	15.4	14.1	9.9	23.0
428+70	407+00	[illegible]	.0021622	46000	11.9	9.9	23.0	10.3	21.9
407+00	403+60	[illegible]	.0021622	46000	11.9	13.8	15.9	14.9	14.5

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

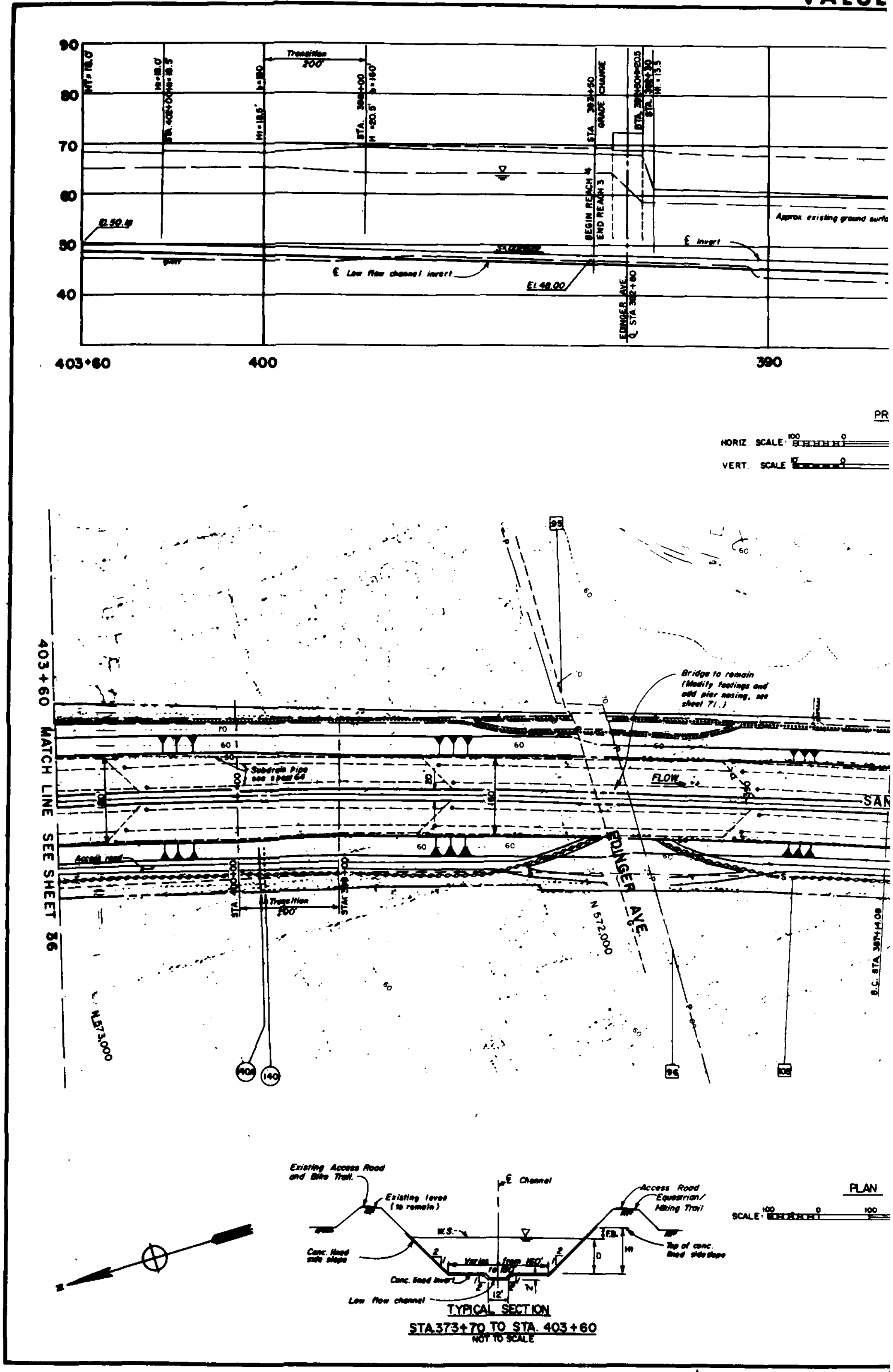
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 403+60 TO STA. 433+50

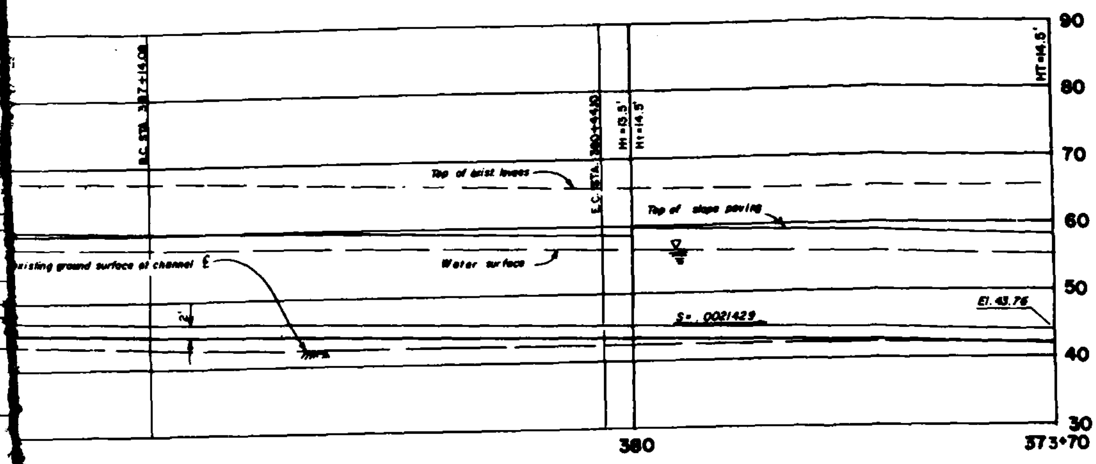
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

SHEET 36 OF 105 SHEETS
PLATE 36

2



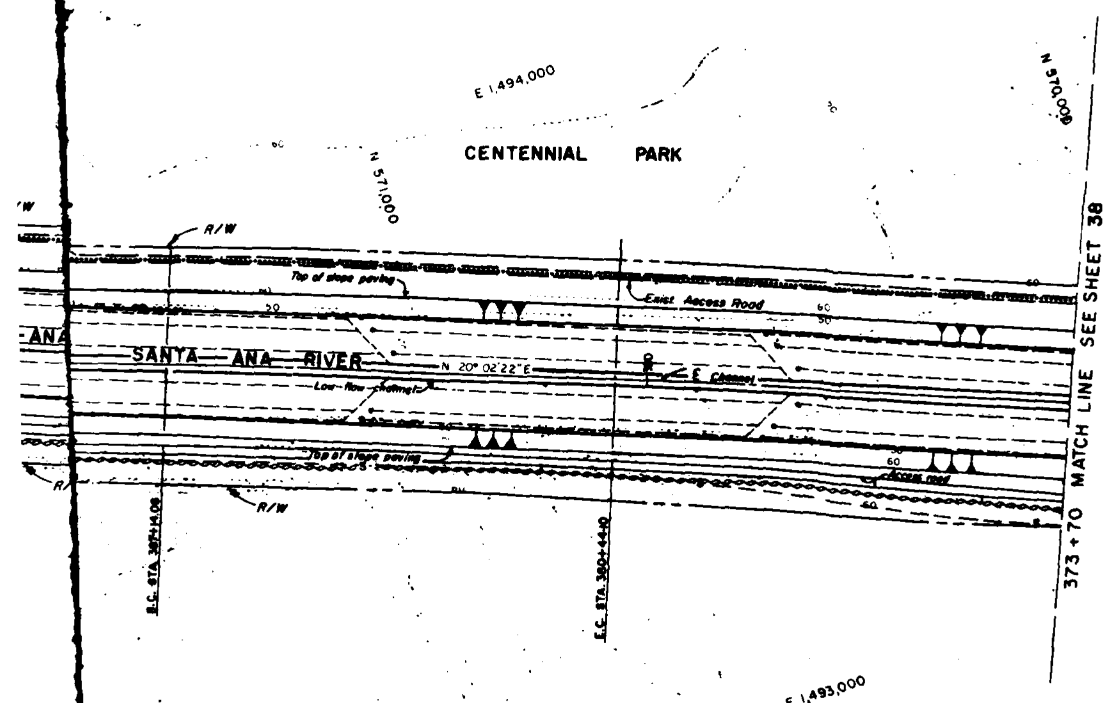
90
80
70
60
50
40
403+60
400
390
Transition 200'
BEGIN REACH 4
END REACH 3
EDINGER AVE. ℄ STA 392+60
℄ Invert
℄ Low flow channel invert
El.48.00
El.50.18
Approx. existing ground surface
PR
HORIZ. SCALE
VERT. SCALE
403+60 MATCH LINE SEE SHEET 86
Bridge to remain (Modify footings and add pier nosing, see sheet 71.)
Subdrain Pipe see sheet 64
FLOW
SAN
EDINGER AVE.
Access road
N 572,000
N 573,000
PLAN
SCALE
Existing Access Road and Bike Trail.
Existing levee (to remain)
℄ Channel
Access Road Equestrian/ Hiking Trail
Conc. lined side slope
Conc. lined invert
Low flow channel
Top of conc. lined side slope
Varies from 160'
12'
TYPICAL SECTION
STA.373+70 TO STA. 403+60
NOT TO SCALE



PROFILE

0 100 200 300 FEET

0 10 20 30 FEET



NOTE:

1. REMOVE EXISTING 4" TO 8" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

NO UTILITY. SEE SHEET 62 FOR TABULATION.

NO SIDE DRAIN. SEE SHEET 70 FOR DETAILS.

EQUESTRIAN/HIKING TRAIL.

EXISTING ACCESS ROAD AND BIKE TRAIL—PROTECT IN PLACE.

PLAN

100 200 300 FEET

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						Da_1	Va_1	Da_2	Va_2
403+60	400+00	[illegible]	.0021622	46000	11.9	14.9	14.5	16.0	13.4
400+00	398+00	TRANS	.0021622	46000	VARIES	16.0	13.4	15.1	13.8
398+00	393+50	[illegible]	.0021622	46000	12.8	15.1	15.8	16.5	14.3
393+50	392+50	[illegible]	.0021429	46000	12.8	16.5	14.3	10.5	23.8
392+50	373+70	[illegible]	.0021429	46000	12.8	10.3	23.8	11.0	22.6

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 373+70 TO STA. 403+60

SUBMITTED BY:

DATE APPROVED:

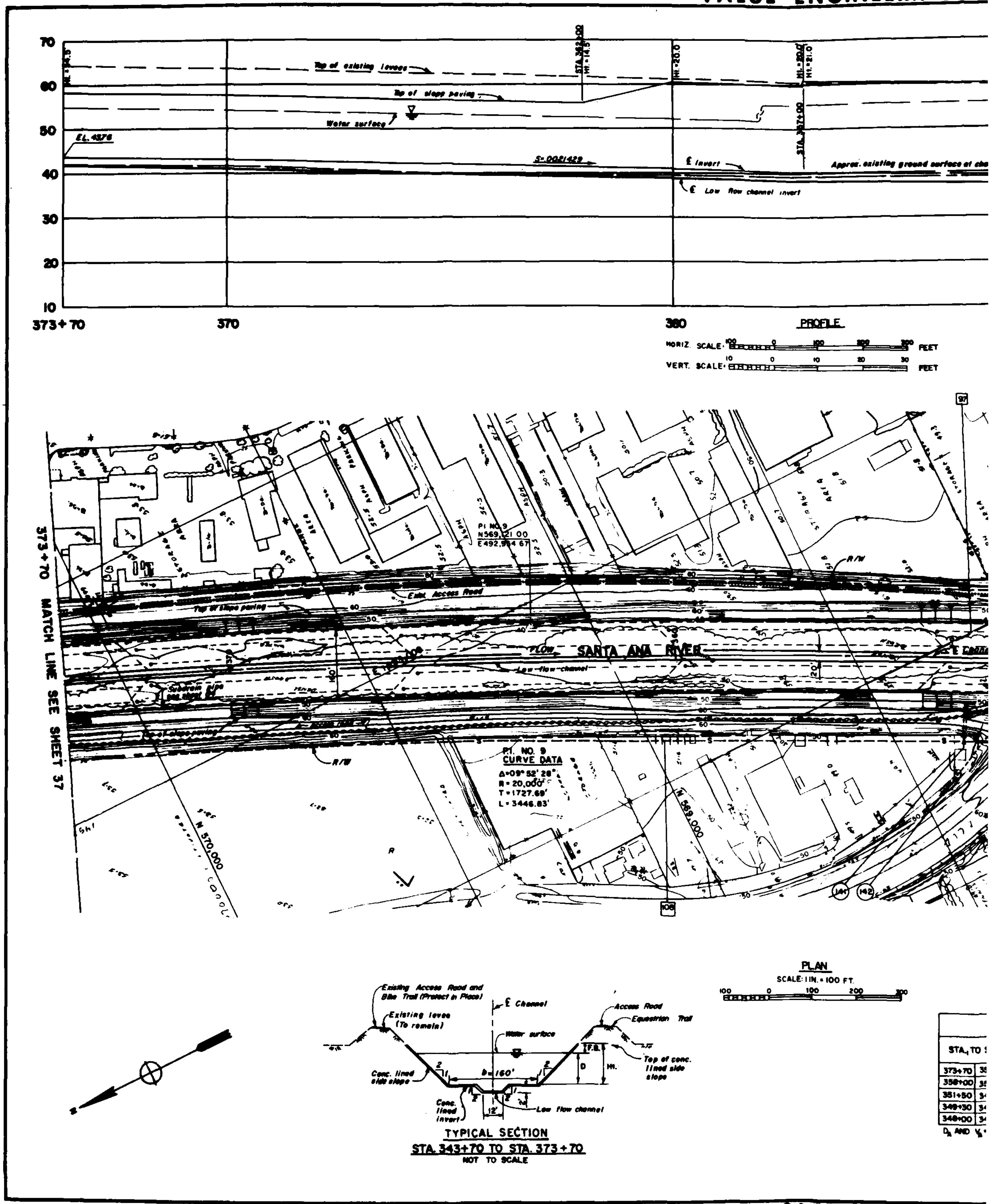
DISTRICT FILE NO.

SHEET 37 OF 105 SHEETS

PLATE 40

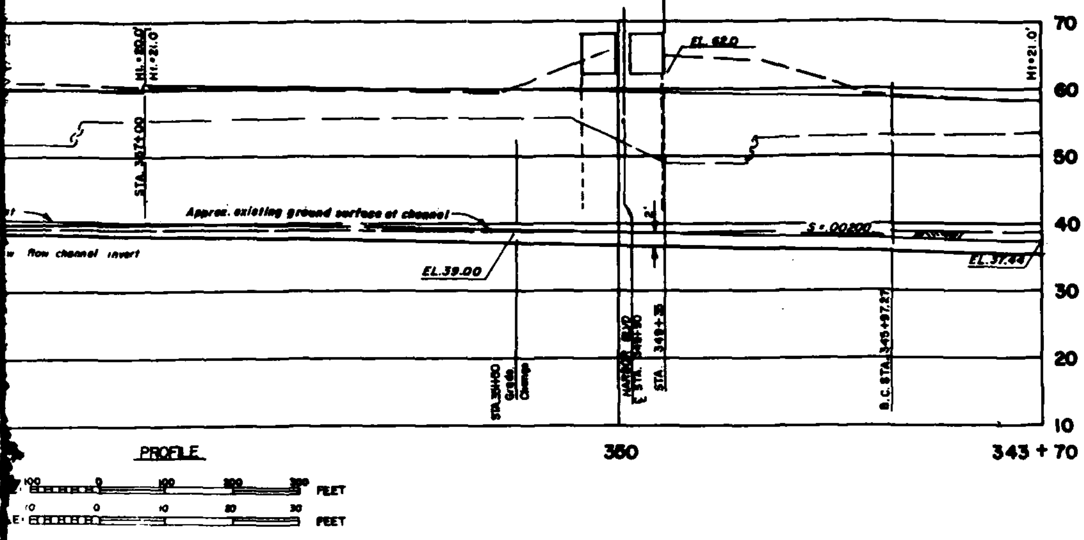
2

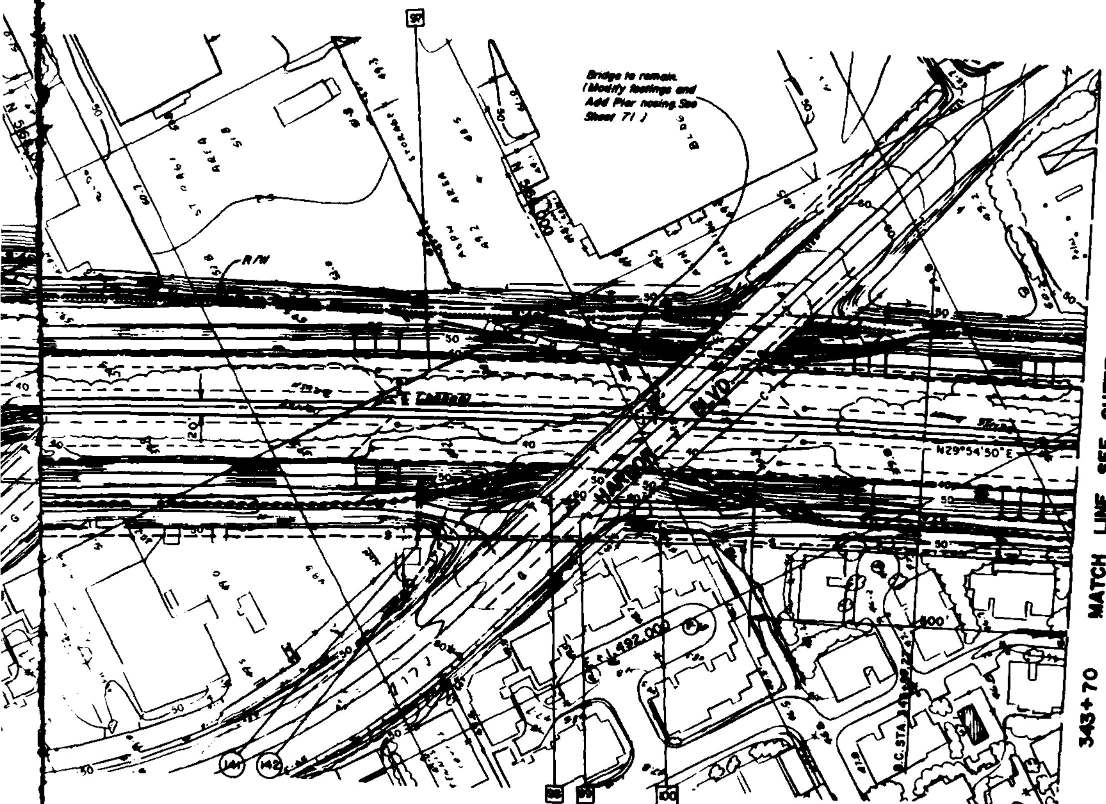
VALUE ENGINEERING P



SAFETY PAYS

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





NOTE:

1. REMOVE EXISTING 4" TO 8" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- NO. UTILITY SEE SEE SHEET 62 FOR TABULATION.
- (NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN/HIKING TRAIL.
- NEW ACCESS ROAD AND BIKE TRAIL.
- EXISTING ACCESS ROAD AND BIKE TRAIL-PROTECT IN PLACE.

PLAN

SCALE: 1 IN. = 100 FT.

HYDRAULIC ELEMENTS									
STA_1 TO STA_2		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
373+70	358+00	[illegible]	.0021429	46000	12.8	11.0	22.6	11.0	22.5
358+00	351+50	[illegible]	.0021429	46000	12.8	14.9	15.9	17.0	13.8
351+50	349+50	[illegible]	.002000	46000	12.8	17.0	13.8	10.1	24.6
349+50	346+00	[illegible]	.002000	46000	12.8	10.1	24.6	10.4	23.9
346+00	343+70	[illegible]	.002000	46000	12.8	14.6	16.4	16.1	14.7

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: gba
CHECKED BY:

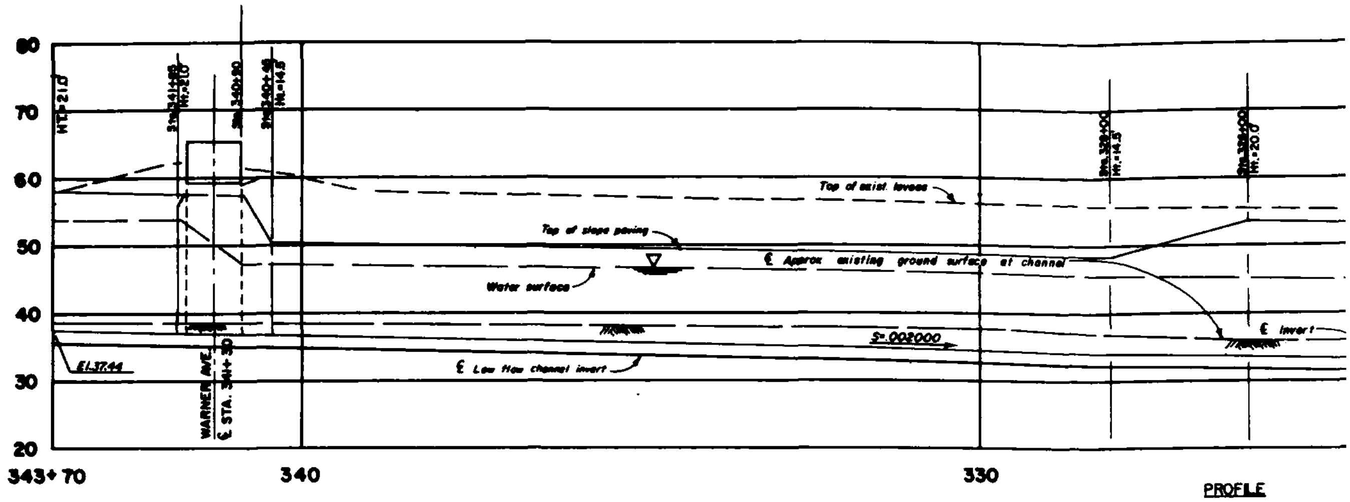
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL PLAN AND PROFILE STA. 343+70 TO STA. 373+70

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 38 OF 105 SHEETS

PLATE 41

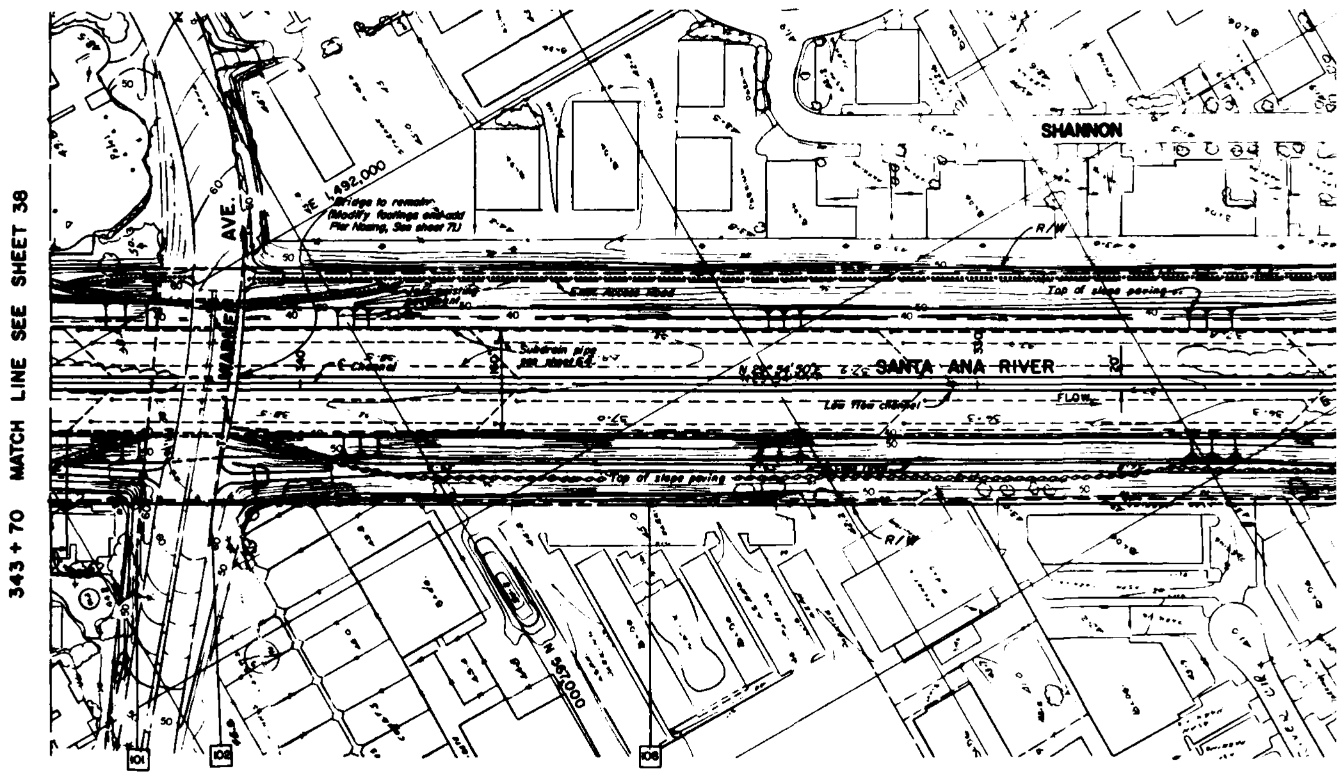
2



PROFILE

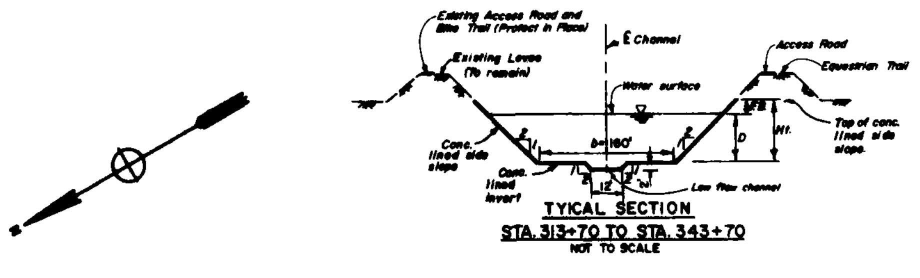
HORIZ. SCALE

VERT. SCALE



PLAN

SCALE

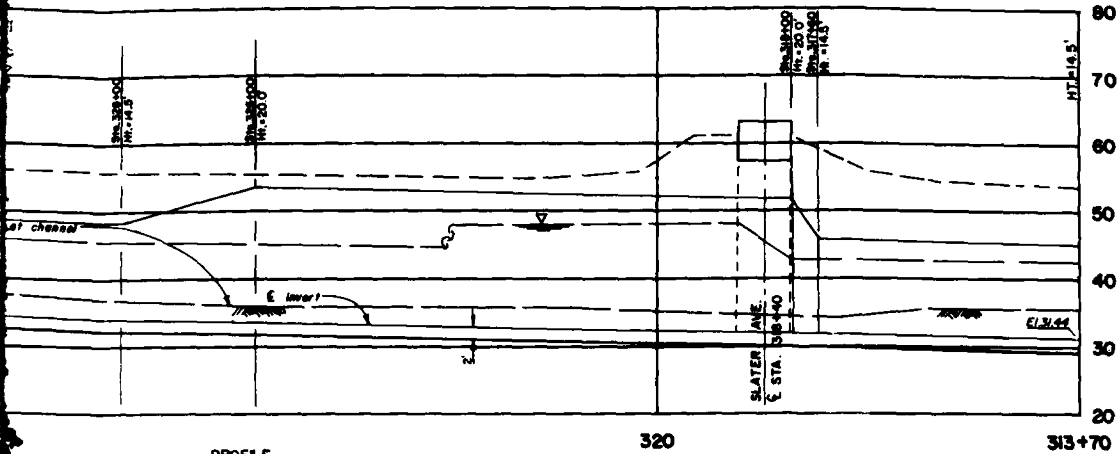


TYICAL SECTION

STA. 313+70 TO STA. 343+70

NOT TO SCALE

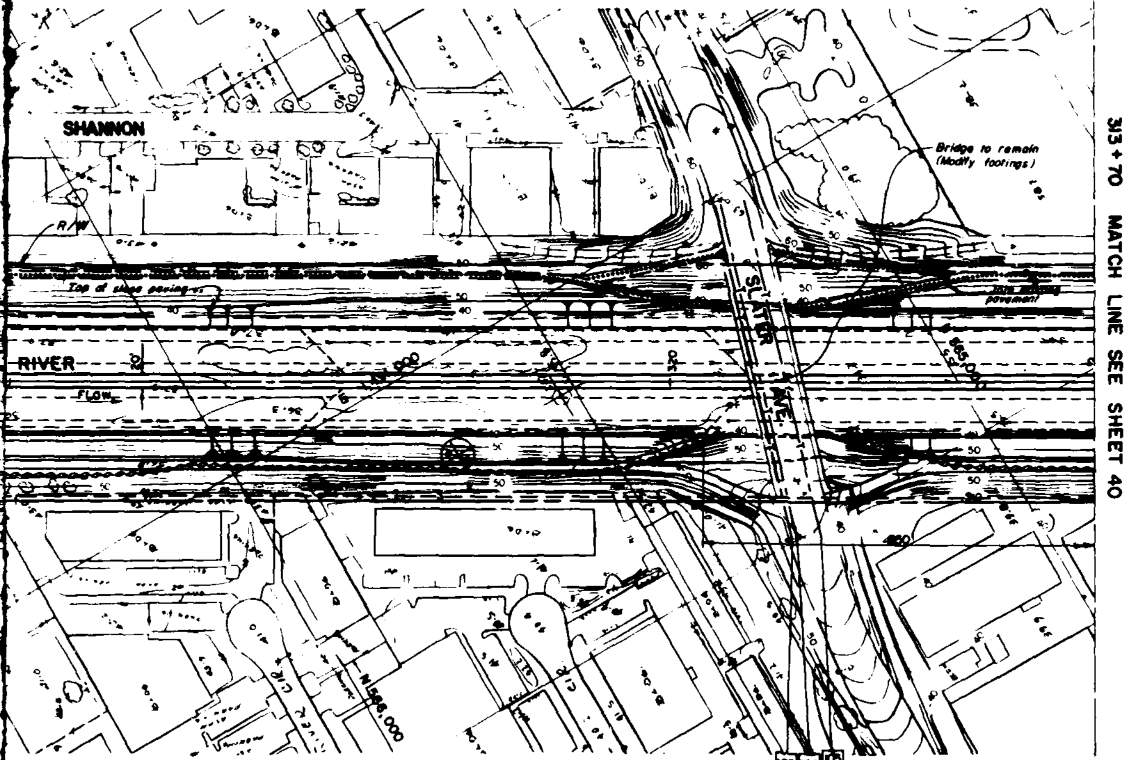
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



PROFILE

HORIZ SCALE: 100 0 100 200 300 FEET

VERT. SCALE 10 0 10 20 30 FEET



PLAN

SCALE 100 0 100 200 300 FEET

NOTES:

1. REMOVE EXISTING 4" TO 8" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

NO.	UTILITY. SEE SHEET 62 FOR TABULATION
	EQUESTRIAN/HIKING TRAIL
	NEW ACCESS ROAD AND BIKE TRAIL
	EXISTING ACCESS ROAD AND BIKE TRAIL - PROTECT IN PLACE.

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
343+70	342+00	TRAP b=180'	.002000	46000	12.8	16.1	14.7	16.5	16.3
342+00	340+90	TRAP b=180'	.002000	46000	12.8	16.5	16.3	10.6	23.6
340+90	323+00	TRAP b=180'	.002000	46000	12.8	10.6	23.6	11.2	22.2
323+00	319+00	TRAP b=180'	.002000	46000	12.8	14.6	16.4	16.2	16.6
319+00	318+00	TRAP b=180'	.002000	46000	12.8	16.2	16.6	10.9	23.1
318+00	313+70	TRAP b=180'	.002000	46000	12.8	10.9	25.1	11.1	22.7

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: DRV

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 313+70 TO STA. 343+70

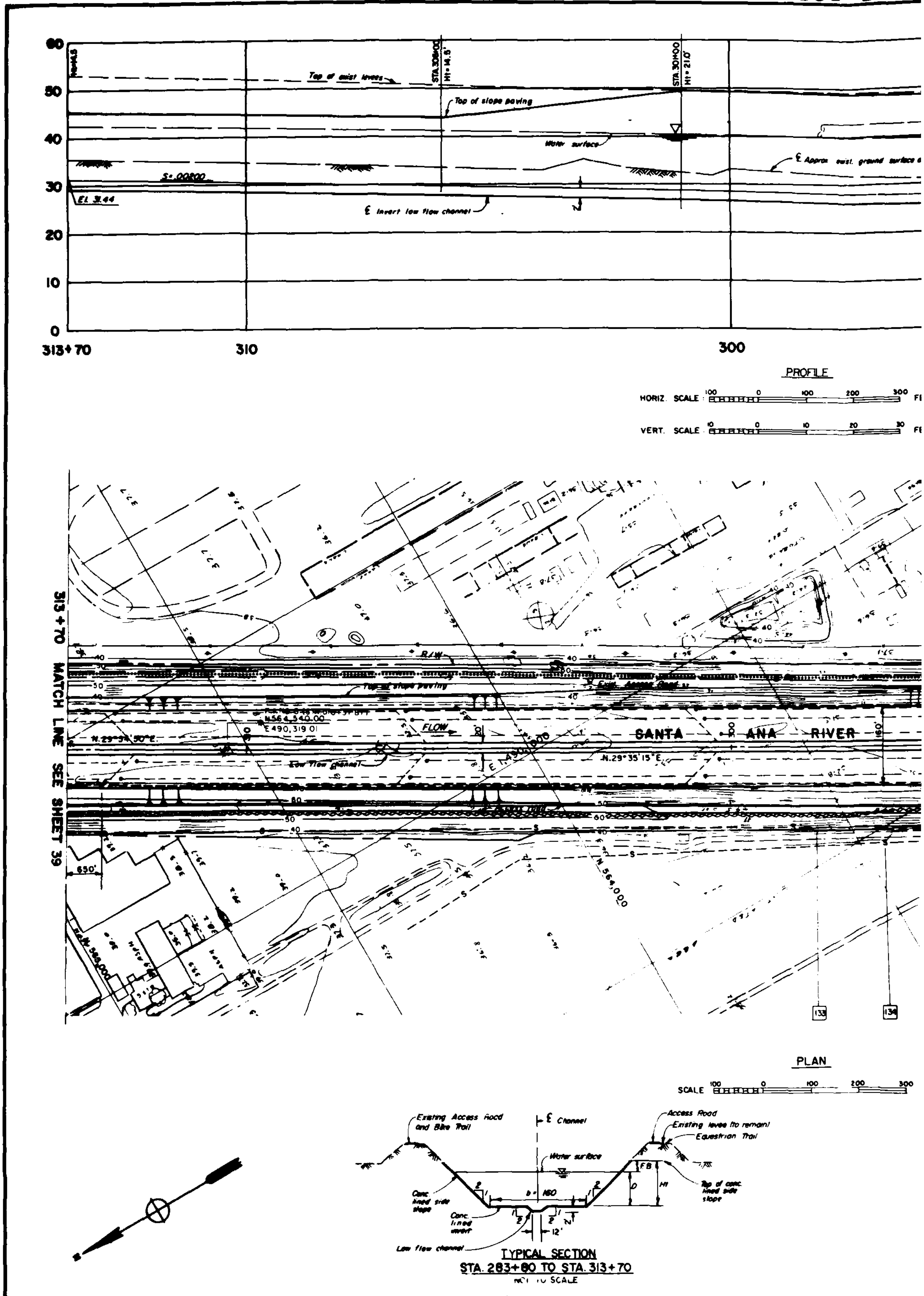
SUBMITTED BY: DATE APPROVED: DISTRICT FILE NO.

SHEET 39 OF 106 SHEETS

PLATE 42

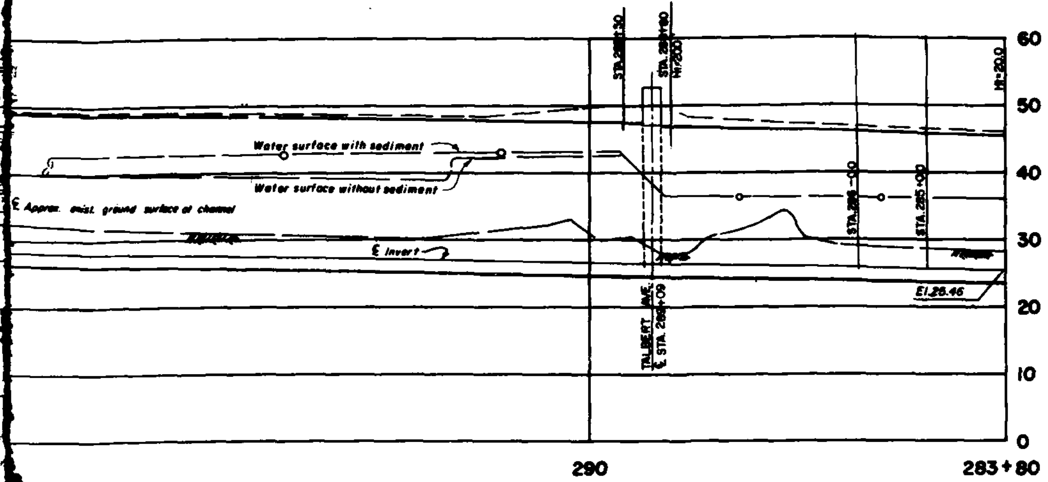
2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



:RING

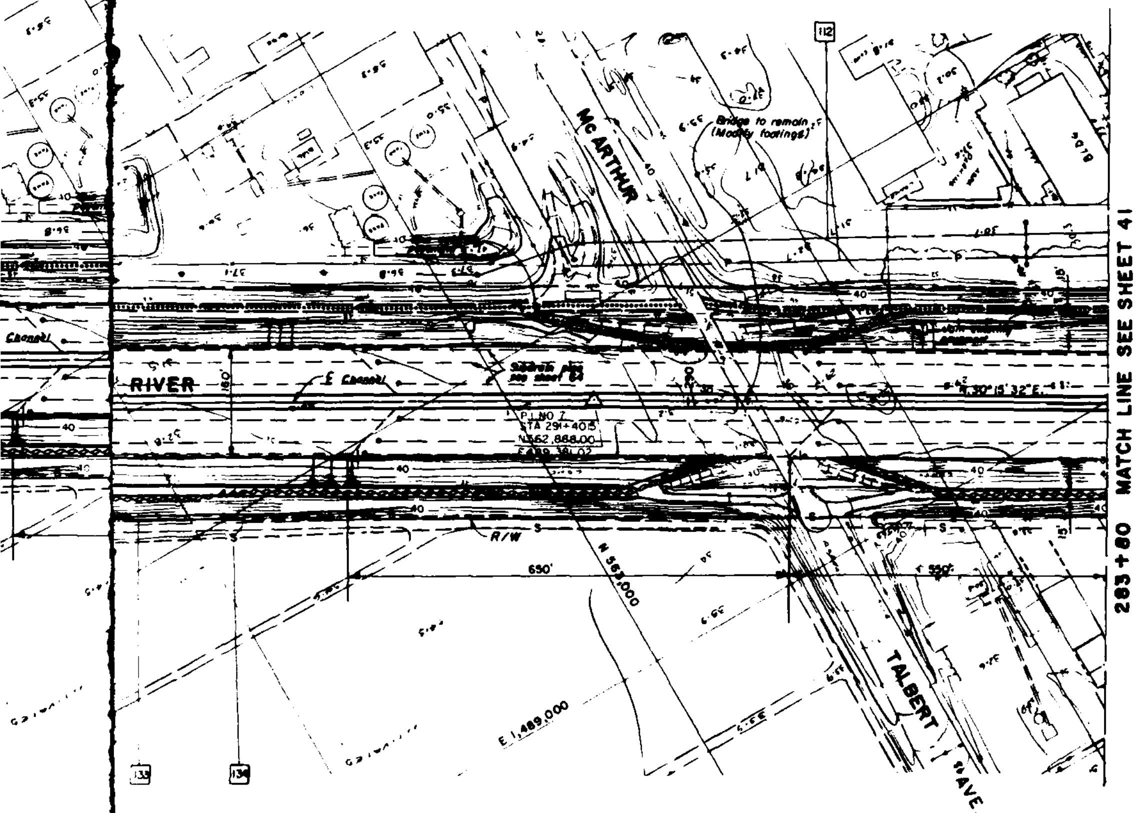
LUE ENGINEERING PAYS



OFILE

100 200 300 FEET

10 20 30 FEET



LAN

100 200 300 FEET

LEGEND

- UTILITY, SEE SHEET 62 FOR TABULATION
- EQUESTRIAN / HIKING TRAIL.
- NEW ACCESS ROAD AND BIKE TRAIL.
- EXISTING ACCESS ROAD AND BIKE TRAIL- PROTECT IN PLACE.

NOTES

1. REMOVE EXISTING 4" TO 8" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
313+70	298+00	[illegible]	.002000	46000	13.0	10.9	22.7	11.2	22.0
298+00	290+00	[illegible]	.002000	46000	13.0	14.7	16.4	17.0	13.8
290+00	289+10	[illegible]	.002000	46000	13.0	17.0	13.8	10.2	24.4
289+10	283+80	[illegible]	.002000	46000	13.0	10.2	24.4	10.8	23.8

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: gma

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 283+80 TO STA. 313+70

CHECKED BY:

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

SHEET 40 OF 106 SHEETS

PLATE 43

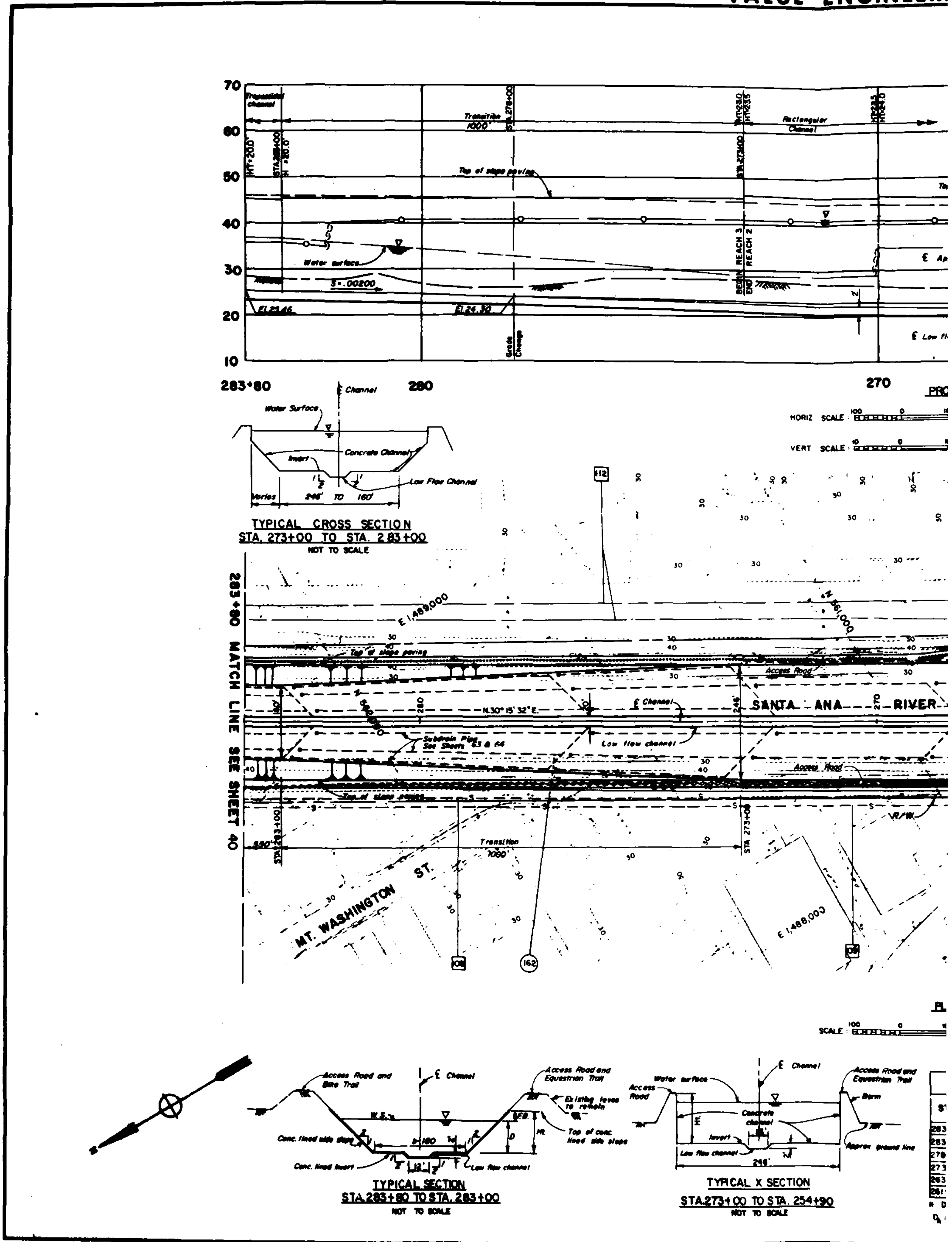
PAYS

SAFETY PAYS

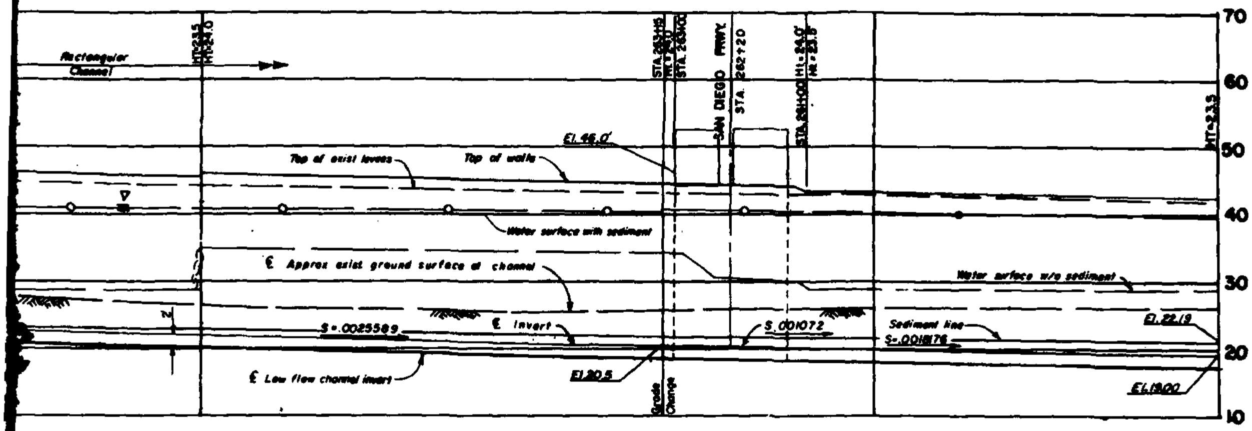
2

VALUE ENGINEERI

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



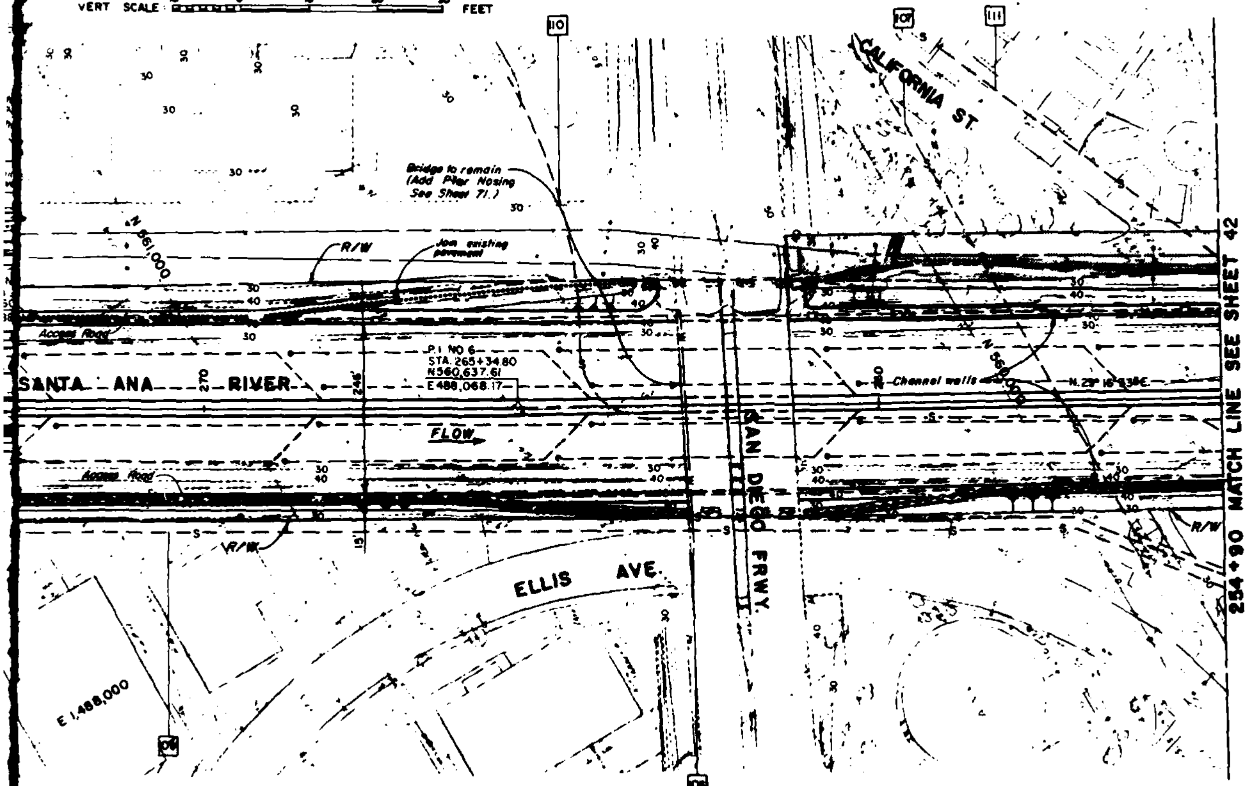
SAFETY PA



PROFILE

HORIZ. SCALE: 100 0 100 200 300 FEET

VERT SCALE: 10 0 10 20 30 FEET



NOTES:

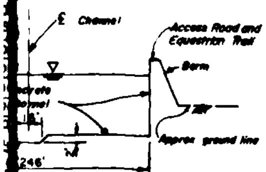
1. REMOVE EXISTING 4" TO 6" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- ADDITIONAL R/W REQUIRED
- NO. UTILITY, SEE SHEET 62 FOR TABULATION
- (NO.) SIDE DRAIN SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL - PROTECT IN PLACE

PLAN

SCALE: 100 0 100 200 300 FEET



X SECTION

TO STA. 254+90

TO SCALE

HYDRAULIC ELEMENTS

STA.₁	TO STA.₂	SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}	n
283+80	283+00	TRAP. [illegible]	.002000	—	46000	13.0	10.6	23.5	10.6	23.4	.014
283+00	278+00	TRANS.	.002000	—	46000	VARIES	10.6	23.4	17.9	11.6	.014
278+00	273+00	TRANS.	.0025089	.001072	46000	VARIES	17.9	11.6	18.1	10.3	.030 *
273+00	263+15	[illegible]	.0025089	.001072	46000	10.3	18.1	10.3	18.1	10.3	.030 *
263+15	261+30	[illegible]	.0018176	.001072	46000	10.3	18.1	10.3	17.8	10.7	.030 *
261+30	254+90	[illegible]	.0018176	.001072	46000	10.3	17.8	10.7	17.4	10.8	.030 *

* DEPTHS AND VELOCITIES ARE BASED ON WITH-SEDIMENT CONDITIONS

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D. VILPPU

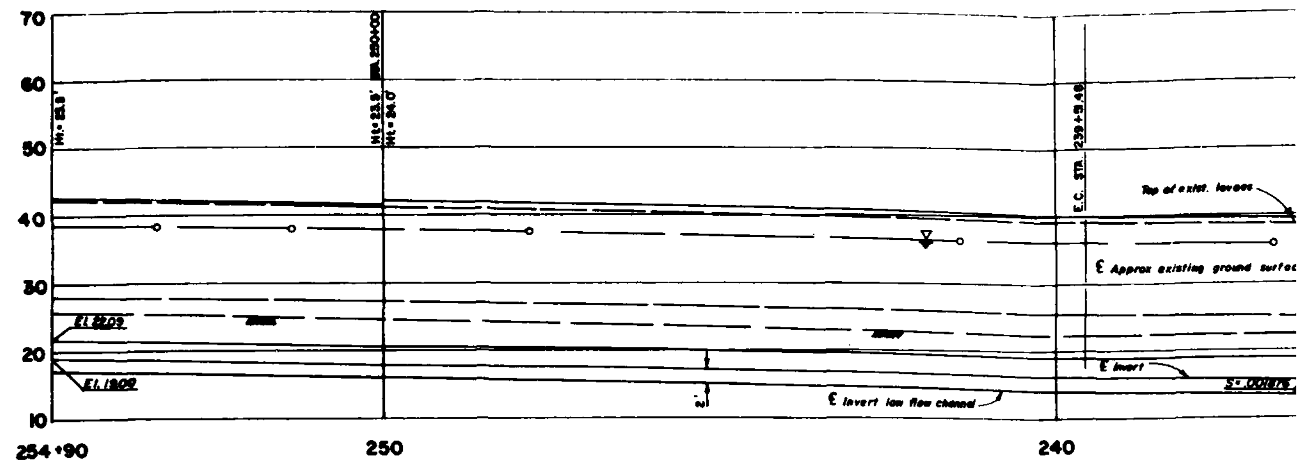
LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 254+90 TO STA. 283+80

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

SHEET 41 OF 105 SHEETS

PLATE 44

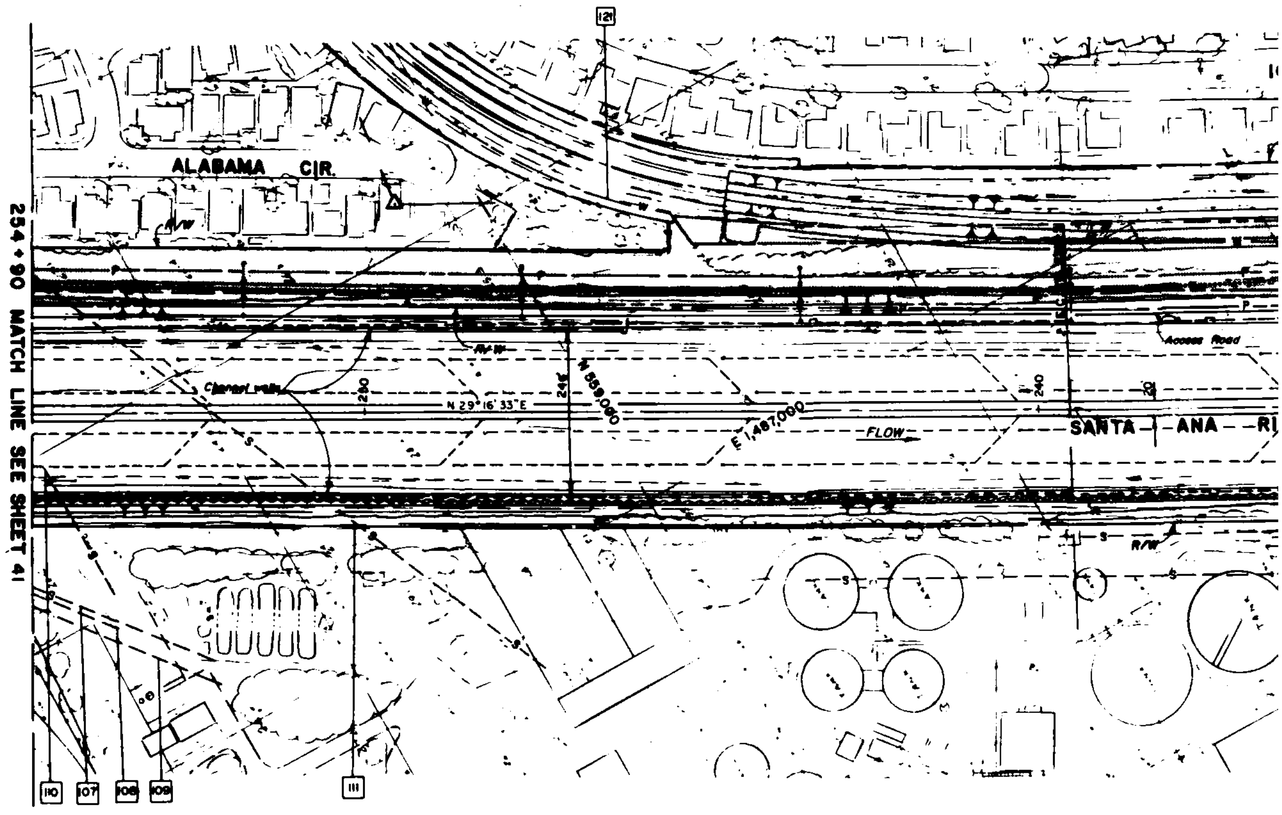
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



PROFILE

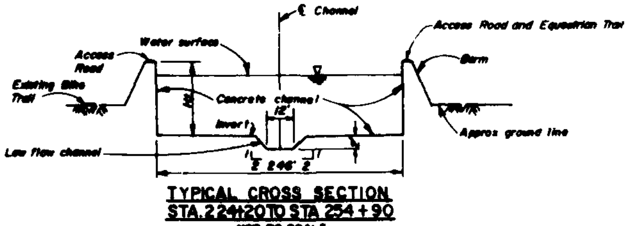
HORIZ. SCALE 100 0 100 200 FEET

VERT. SCALE 10 0 10 20 30 FEET



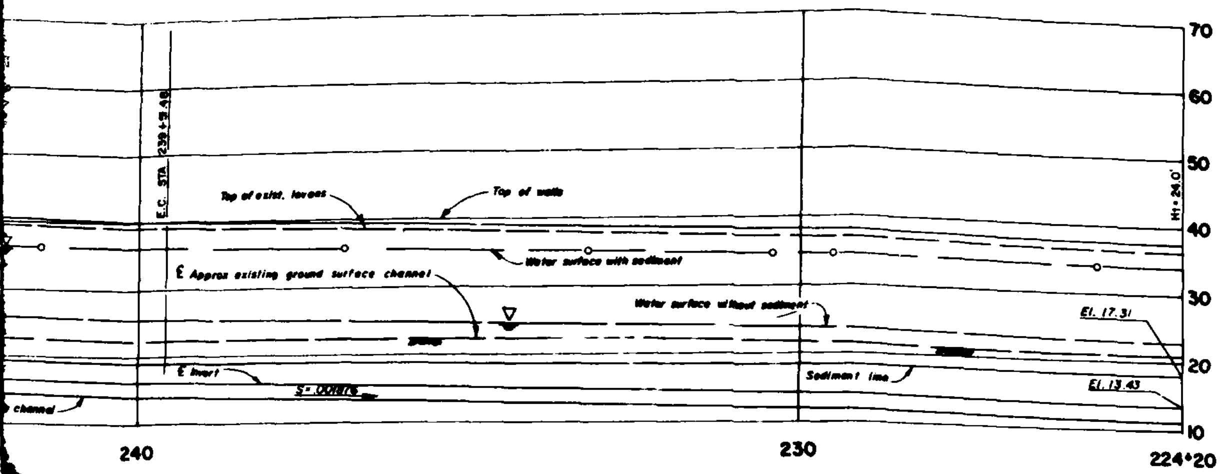
PLAN

SCALE 100 0 100 200 300 FEET



TYPICAL CROSS SECTION
STA. 224+20 TO STA. 254+90
NOT TO SCALE

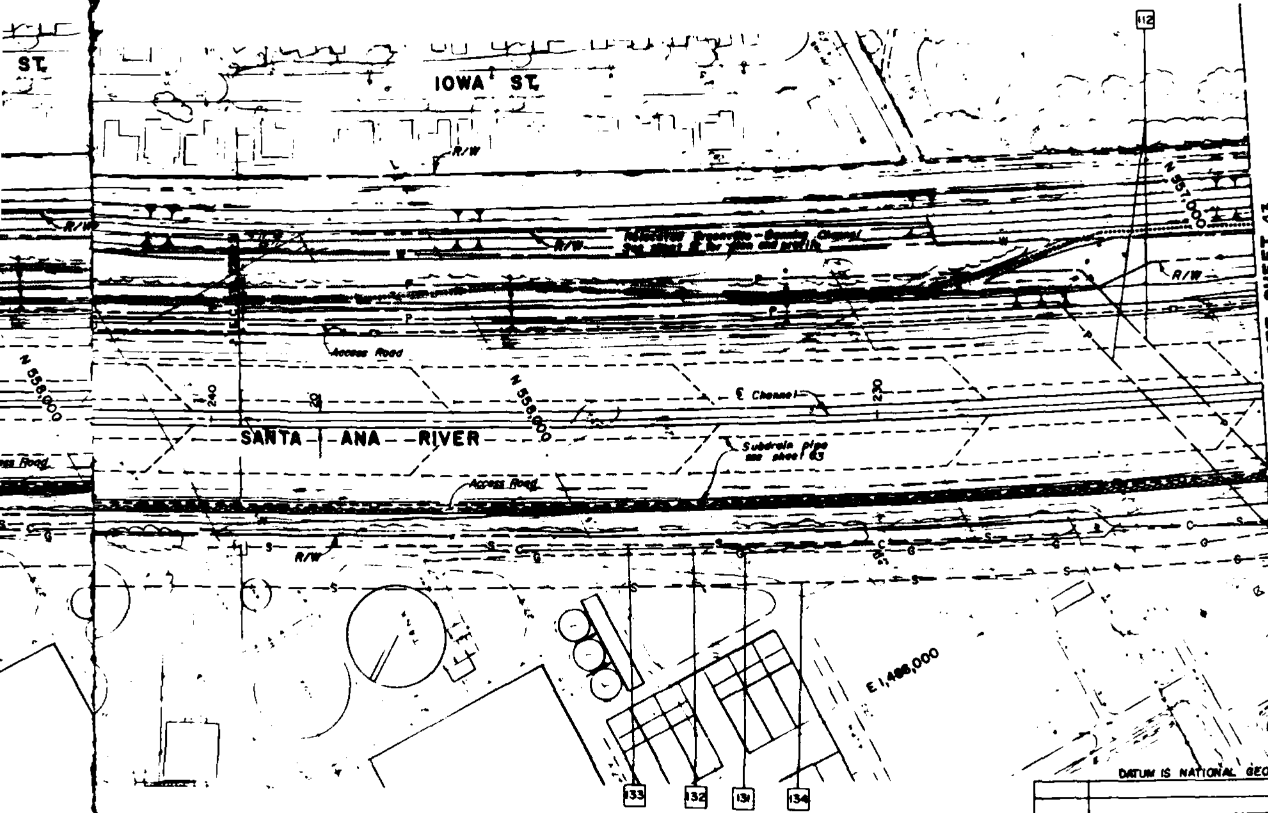
VALUE ENGINEERING PAYS



PROFILE

HORIZ SCALE 100 0 100 200 FEET

VERT SCALE 10 0 10 20 30 FEET



LEGEND

- ADDITIONAL R/W REQUIRED
- EQUESTRIAN/HIKING TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE
- NO — UTILITY SEE SHEET 62 FOR TABULATION

NOTE

1. REMOVE EXISTING 4"-8" REINFORCED CONCRETE FORM SIDE SLOPES
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

PLAN

SCALE 0 100 200 300 FEET

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	SED SLOPE	Q (cfs)	Dc (ft)	n = 0.030			
							D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
254+90	248+00	[illegible]	.001876	.001072	46,000	10.3	17.4	10.8	17.2	10.9
248+00	224+20	[illegible]	.001876	.001072	46,000	10.3	17.2	10.9	16.2	11.6

* DEPTHS AND VELOCITIES ARE BASED ON WITH-SEDIMENT CONDITIONS
D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

SAFETY PAYS

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

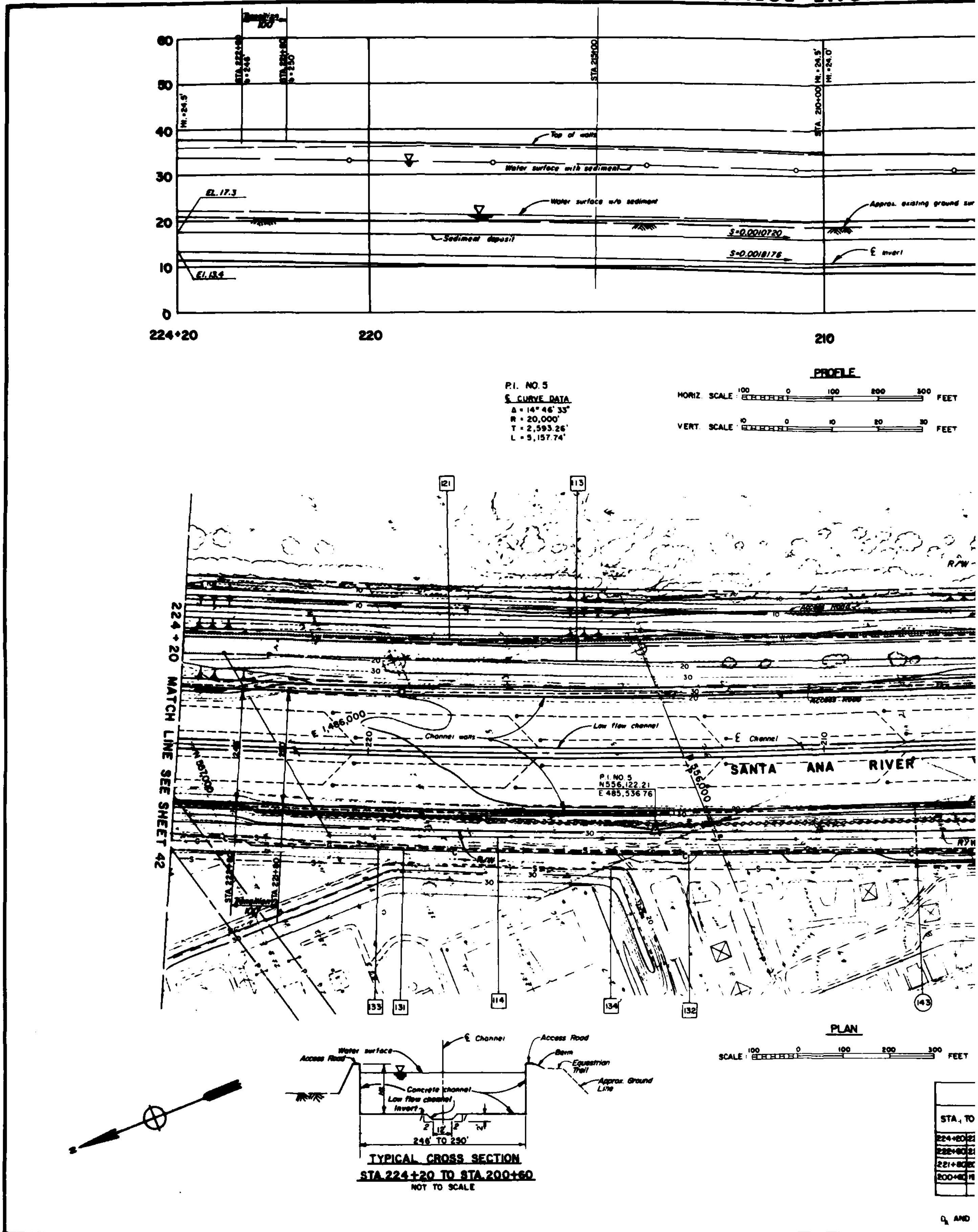
SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 224+20 TO STA. 254+90

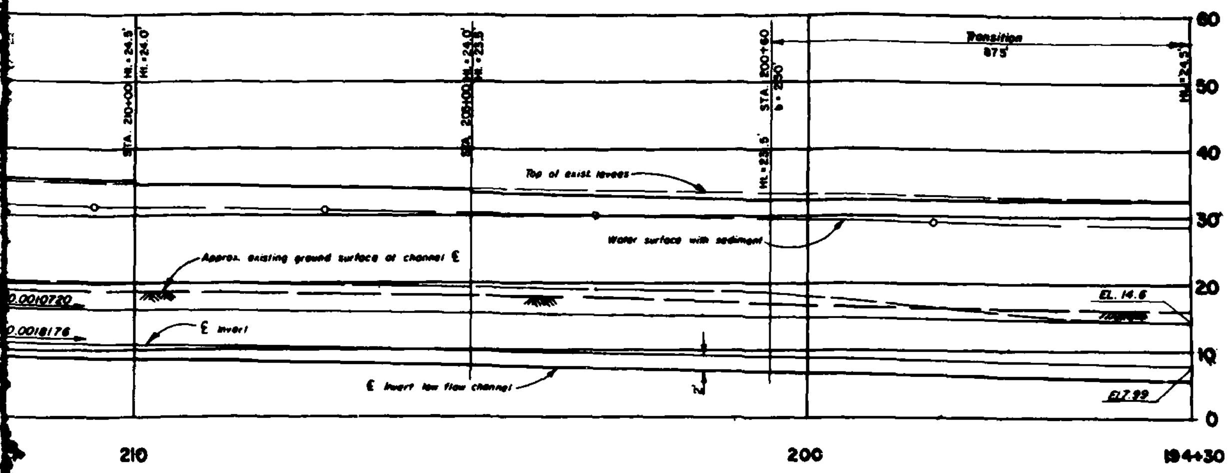
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 42 OF 105 SHEETS

PLATE 45

2



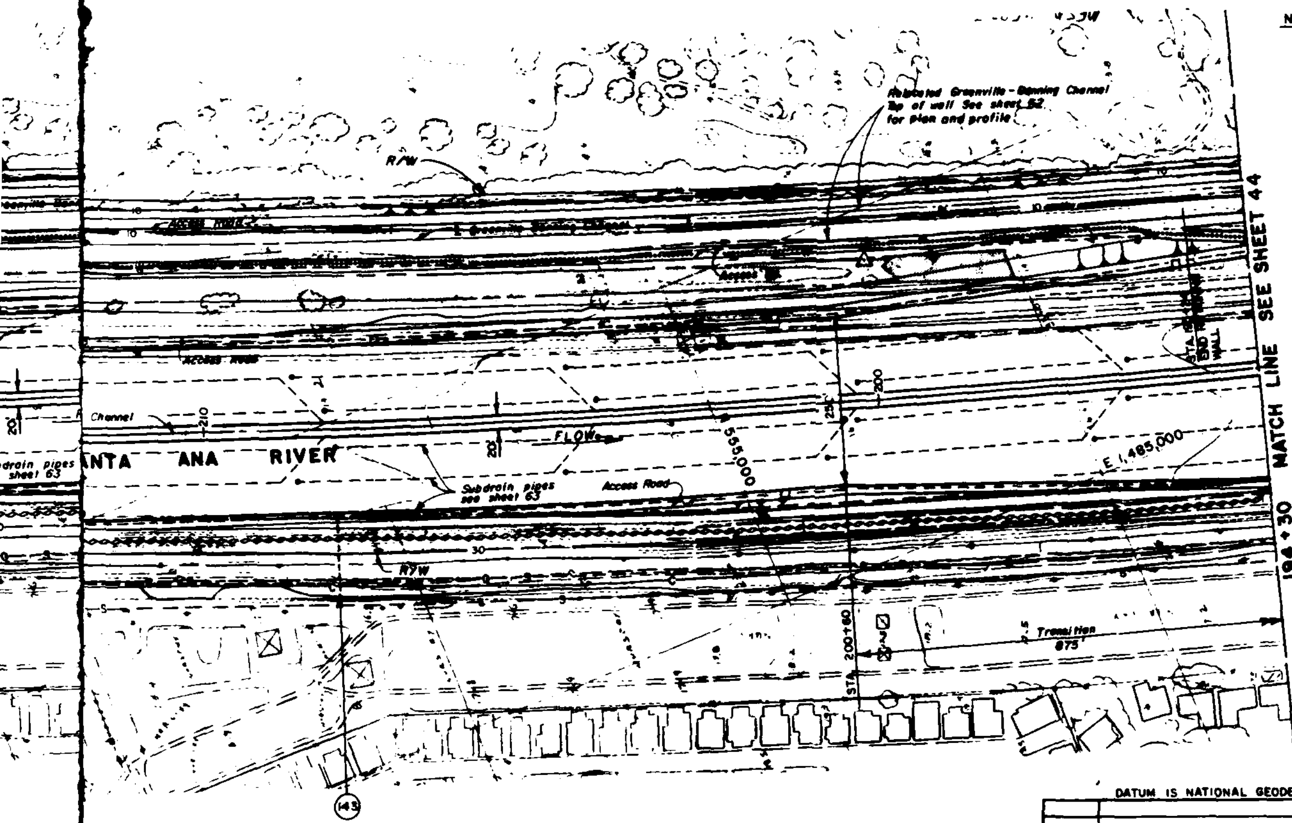
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



PROFILE

FEET

FEET



PLAN

FEET

NOTE:

1. REMOVE EXISTING 6" REINFORCED CONCRETE
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C PAVING DETAILS.

LEGEND

- ADDITIONAL R/W REQUIRED
- NO. UTILITY SEE SHEET 62 FOR TABULATION.
- NO. SIDE DRAIN. SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL.

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030 ✻			
							D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
224+60	222+60	RECT. b=265	.0018176	.0010720	46,000	10.3	16.2	11.6	16.1	11.6
222+60	221+60	TRANS.	.0018176	.0010720	46,000	VARIES	16.1	11.6	16.1	11.5
221+60	200+60	RECT. b=250	.0018176	.0010720	46,000	10.2	16.1	11.5	13.2	14.0
200+60	191+85	TRANS.	.0018176	.0010720	46,000	VARIES	13.2	14.0	13.9	9.1

✻ DEPTHS AND VELOCITIES ARE BASED ON WITH-SEDIMENT CONDITIONS.
D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: Fabre Lamar
P.Penaluetti
CHECKED BY:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

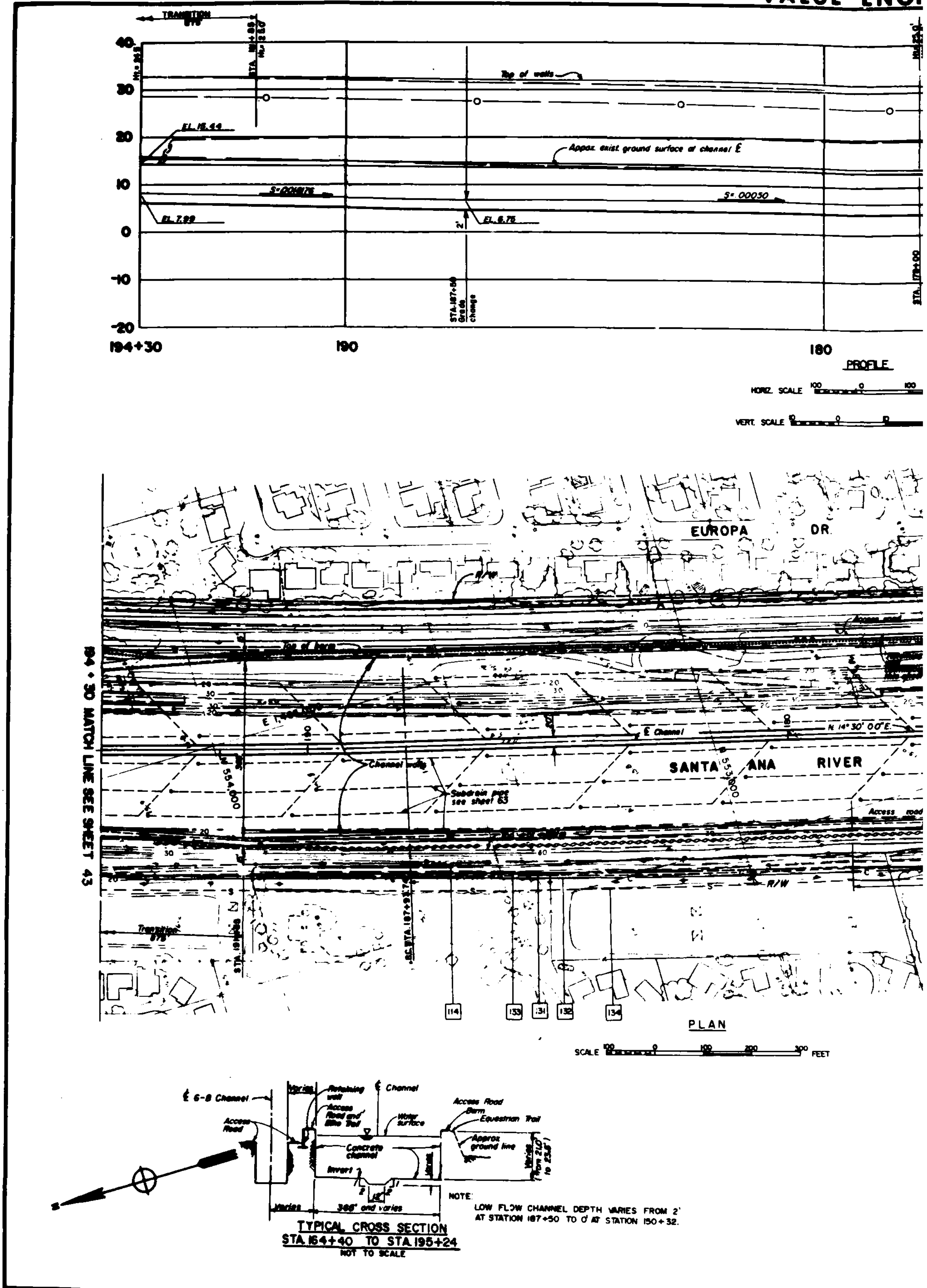
LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 194+30 TO STA. 224+20

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 43 OF 105 SHEETS

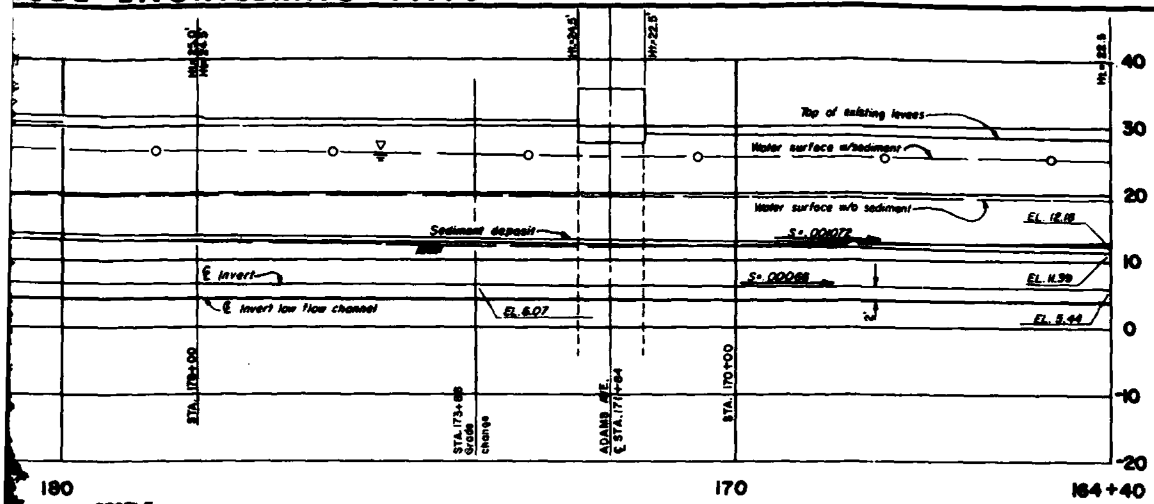
PLATE 46

2

VALUE ENGI



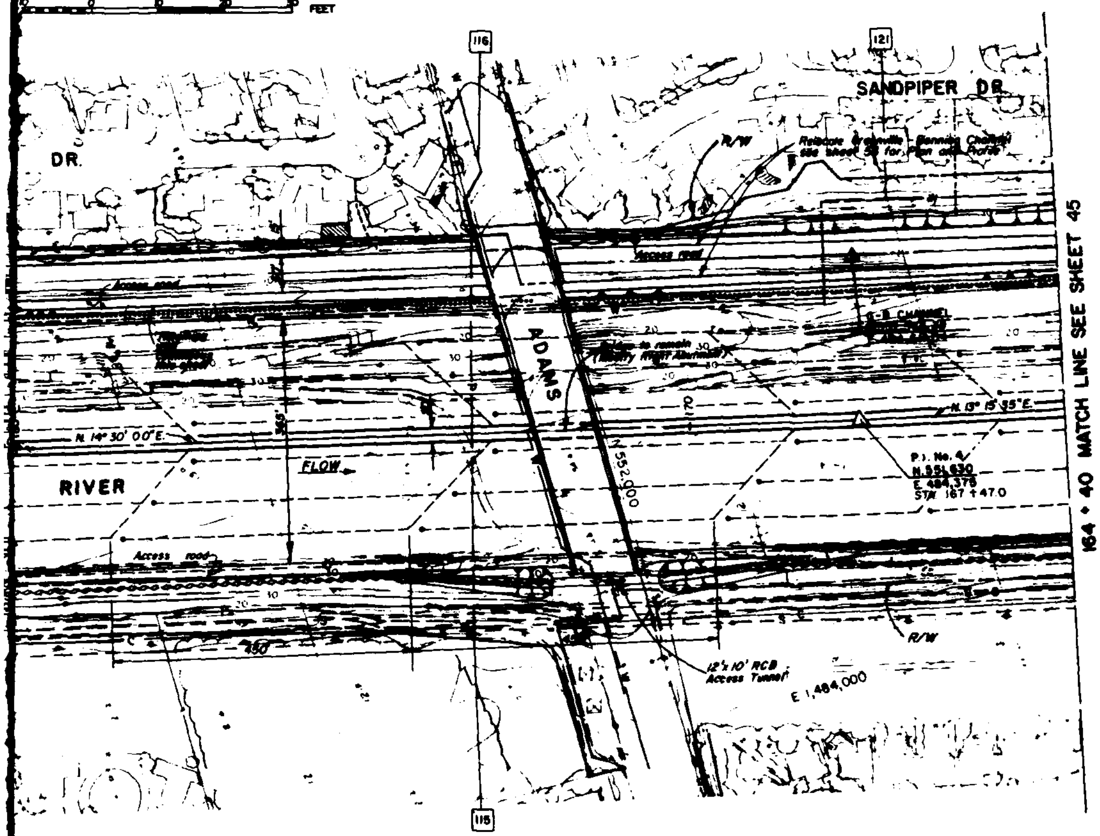
SAFETY



PROFILE

SCALE 100 0 100 200 FEET

10 0 10 20 30 FEET



LEGEND

- ADDITIONAL R/W REQUIRED
- [NO.] UTILITY. SEE SHEET 62 FOR TABULATION.
- EQUESTRIAN / HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL

NOTE:

1. REMOVE EXISTING 6" REINFORCED CONCRETE FROM SIDE SLOPES.

HYDRAULIC ELEMENTS

STA_1 TO	STA_2	SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030* Da_1	Va_1	Da_2	Va_2
164+40	171+40	365 Rect.	.00066	.001072	48000	7.9	13.4	9.4	13.6	9.3
171+40	172+30	365 Rect.	.00066	.001072	48000	7.9	13.6	9.3	13.7	9.2
172+30	173+86	365 Rect.	.00066	.001072	48000	7.9	13.7	9.2	13.7	9.2
173+86	187+50	365 Rect.	.0005	.001072	48000	7.9	13.7	9.2	13.8	9.1
187+50	191+85	365 Rect.	.0005	.001072	48000	7.9	13.8	9.1	13.9	9.1
191+85	200+60	Transition	.00[illegible]78	.001072	48000	Varies	13.9	9.1	13.2	14.0

* DEPTHS AND VELOCITIES ARE BASED ON WITH-SEDIMENT CONDITIONS
D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

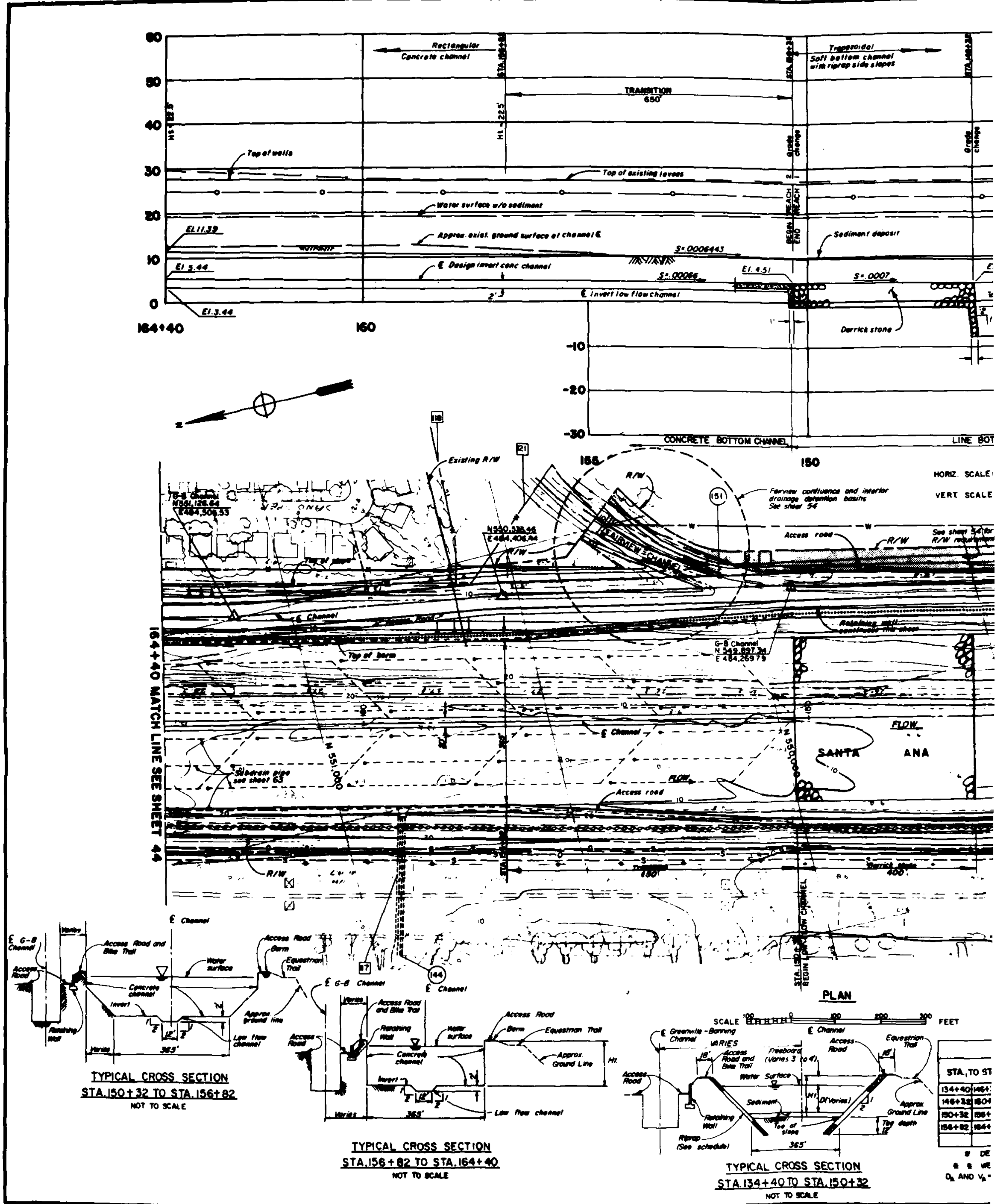
DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 164 + 40 TO STA. 194 + 30

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 44 OF 109

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

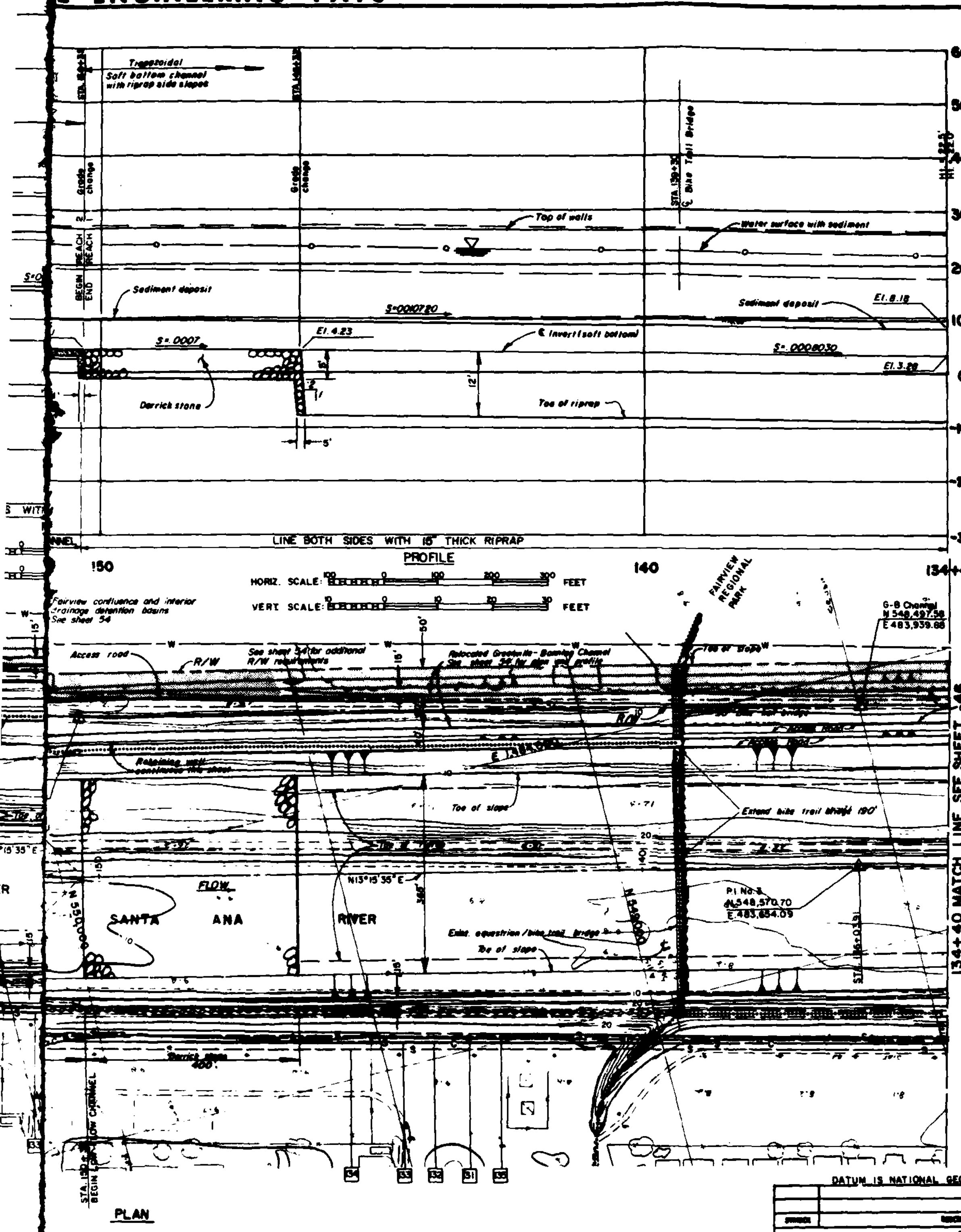


TYPICAL CROSS SECTION
STA. 150+32 TO STA. 156+82
NOT TO SCALE

TYPICAL CROSS SECTION
STA. 156+82 TO STA. 164+40
NOT TO SCALE

TYPICAL CROSS SECTION
STA. 134+40 TO STA. 150+32
NOT TO SCALE

STA. TO ST
134+40 146+
146+32 150+
150+32 156+
156+82 164+

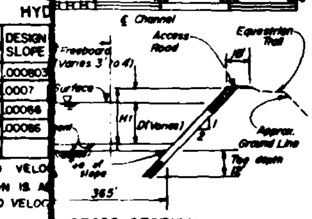


NOTE:

1. REMOVE EXISTING 6" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS

LEGEND

- ADDITIONAL R/W REQUIRED
- (NO.) UTILITY. SEE SHEET 62 FOR TABULATION.
- (NO.) SIDE DRAIN SEE SHEET 70 FOR DETAILS.
- EQUESTRIAN/HIKING TRAIL
- NEW ACCESS ROAD AND BIKE TRAIL
- EXISTING BIKE TRAIL-PROTECT IN PLACE



CROSS SECTION
STA. 134+40 TO STA. 150+32
NOT TO SCALE

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q	DC	n = .030 # D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}	RIPRAP THICKNESS ## DRY	WET
134+40	146+32	365' TRAP	.000803	.001072	46,000	7.5	13.3	8.5	13.5	8.3	15"	24"
146+32	150+32	365' TRAP	.0007	.001072	46,000	7.5	13.5	8.3	13.6	8.2		
150+32	156+82	TRAN	.00086	.001072	46,000	VARIES	13.6	8.2	13.2	9.3		
156+82	164+40	365' RECT	.00086	.001072	46,000	7.9	13.2	9.5	13.4	9.4		

\# DEPTHS AND VELOCITIES ARE BASED ON WITH-SEDIMENT CONDITIONS
\## WET CONDITION IS ASSUMED AT ELEV. 0.0 MSL AND BELOW
D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: F. Castellanos
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 134 + 40 TO STA. 164 + 40

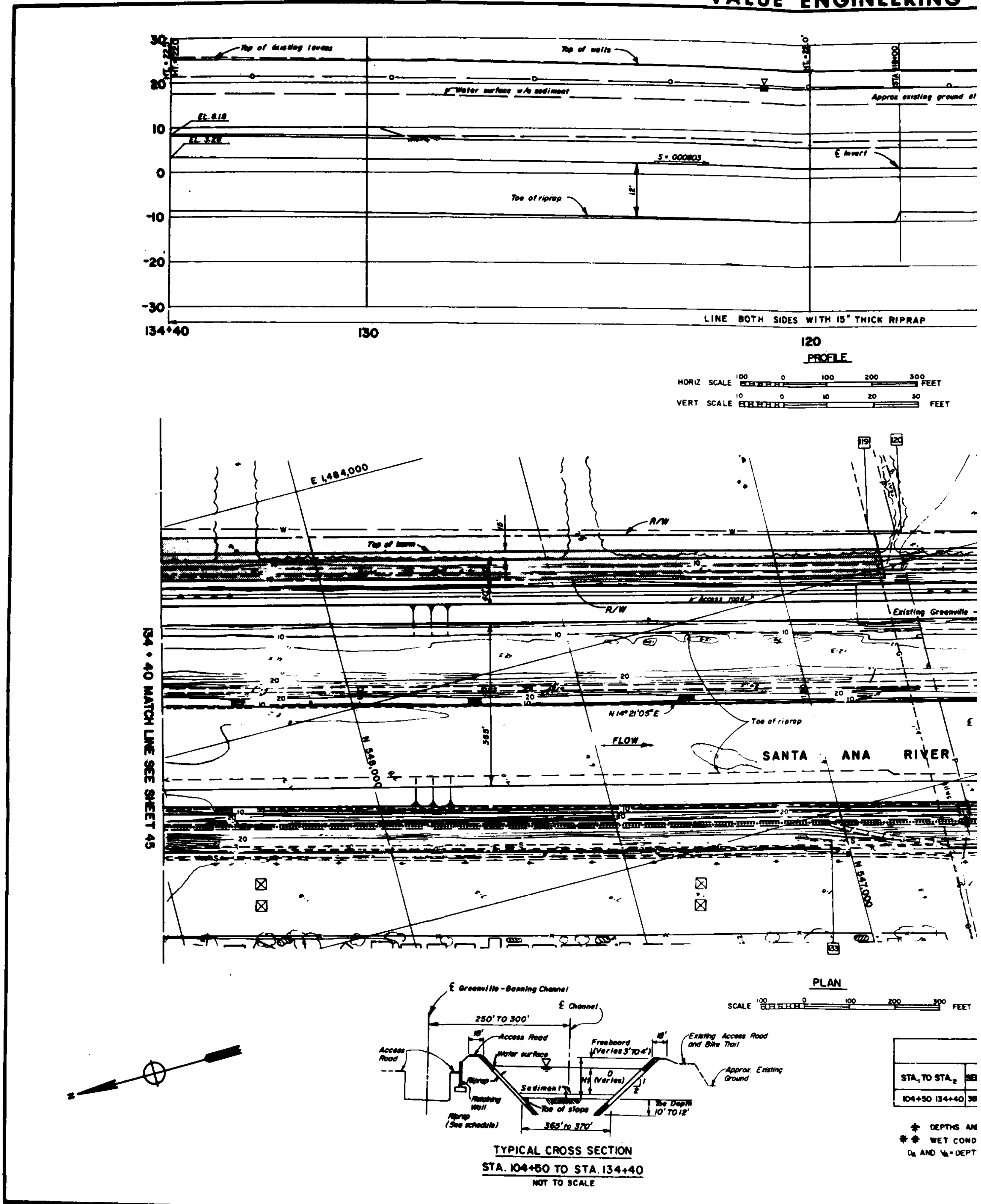
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 45 OF 105 SHEETS

PLATE 40

1

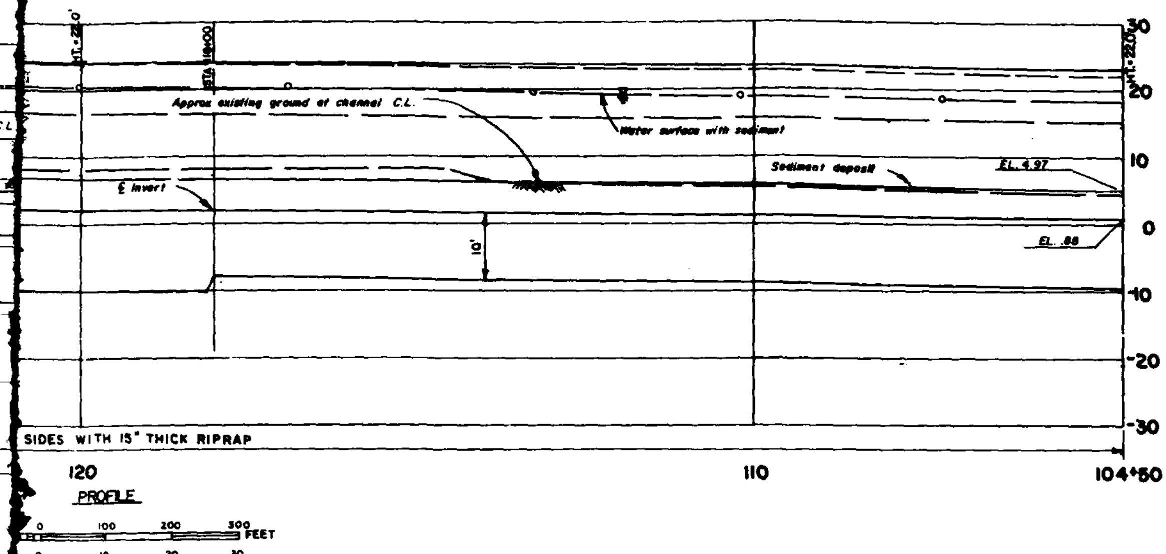
2

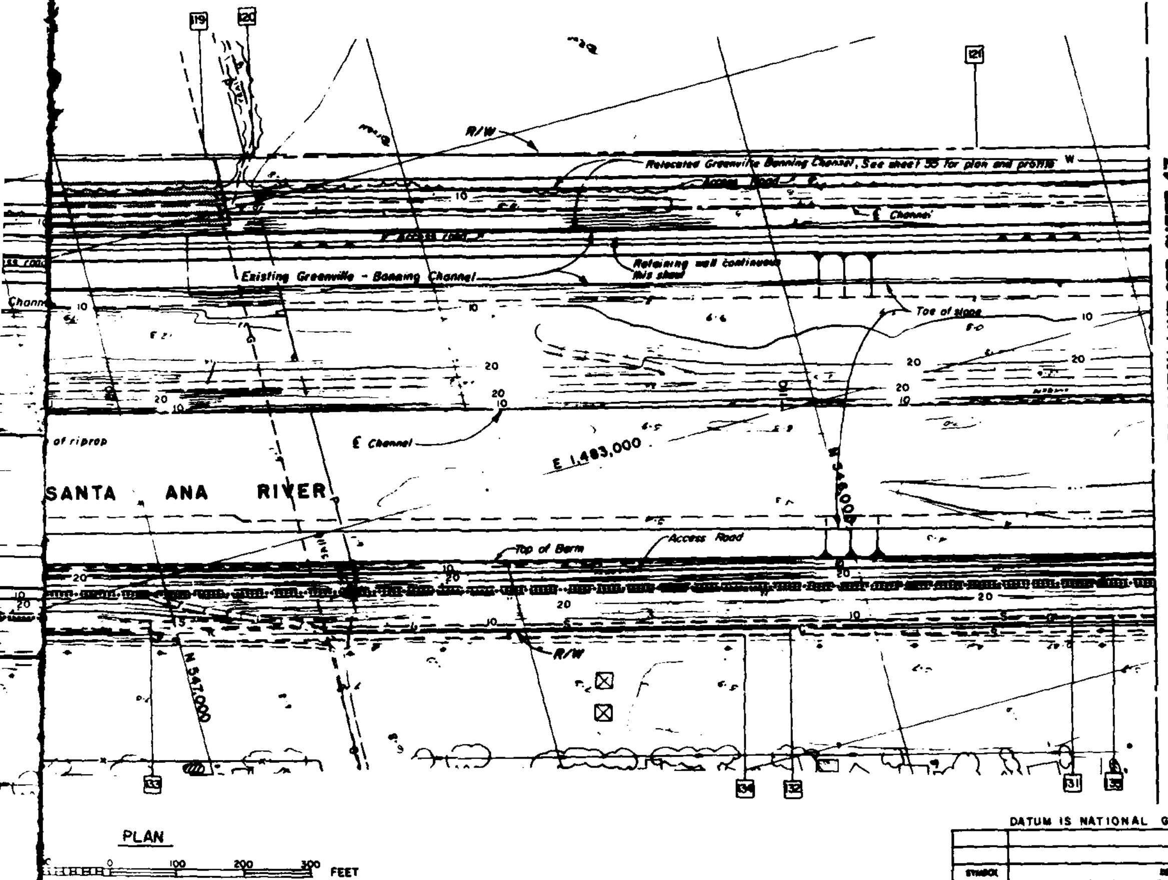
VALUE ENGINEERING



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY PAYS





NOTE:

1. REMOVE EXISTING 6" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

ADDITIONAL R/W REQUIRED

EXISTING BIKE TRAIL-PROTECT IN PLACE

UTILITY. SEE SHEET 62 FOR TABULATION.

HYDRAULIC ELEMENTS											
STA.$_1$ TO STA.$_2$	SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030 *				RIPRAP THICKNESS **	
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}	DRY	WET
104+50 134+40	365' TRAP	.000803	.001072	46000	7.6	13.2	6.4	13.3	6.5	18"	24"

* DEPTHS AND VELOCITIES ARE BASED ON WITH - SEDIMENT CONDITIONS

** WET CONDITION IS ASSUME AT ELEV. 0.0 M.S.L. AND BELOW

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY:

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 104 + 50 TO STA. 134 + 40

SUBMITTED BY:

DATE APPROVED:

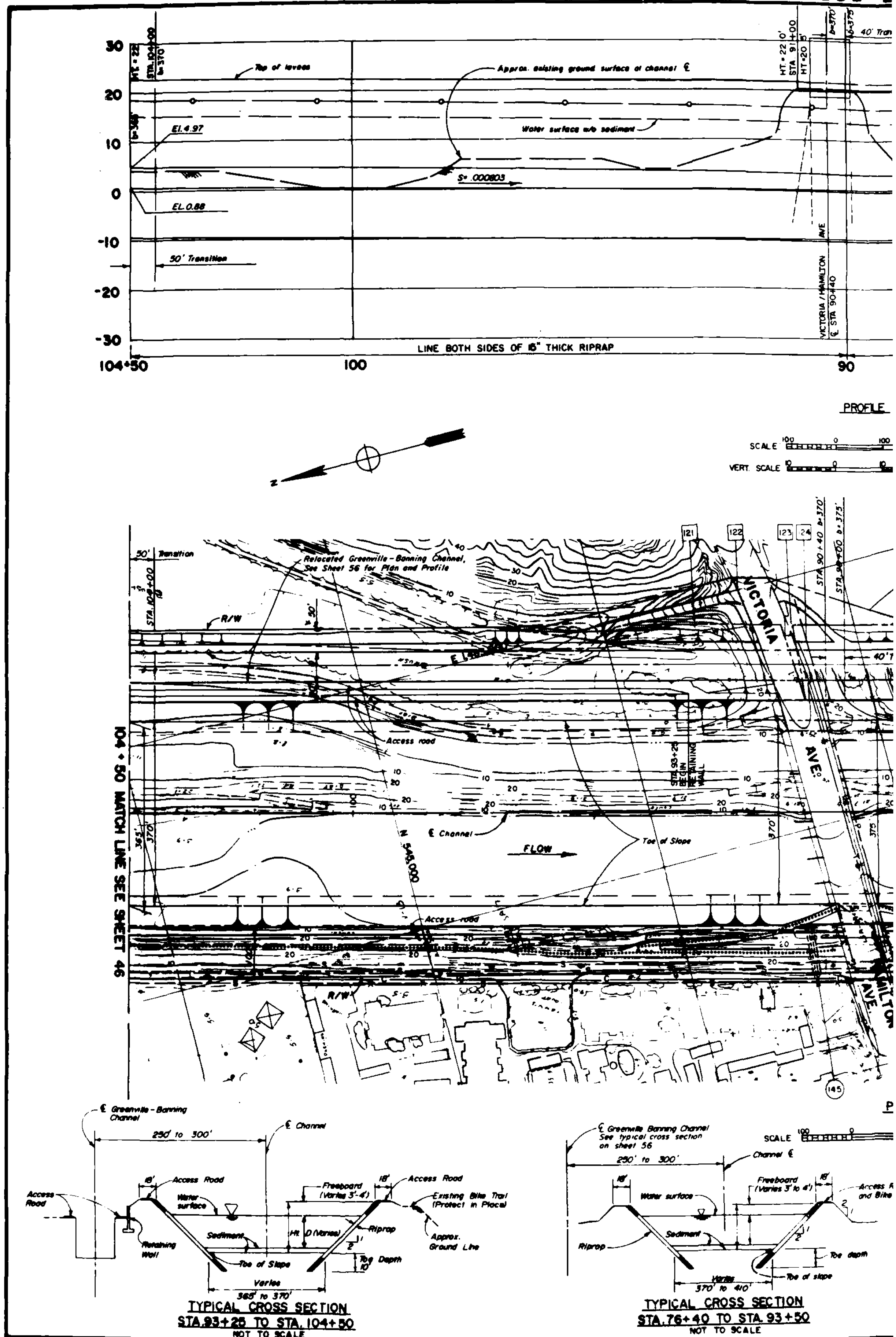
DISTRICT FILE NO.

SHEET 46 OF 105 SHEETS

PLATE [illegible]

2

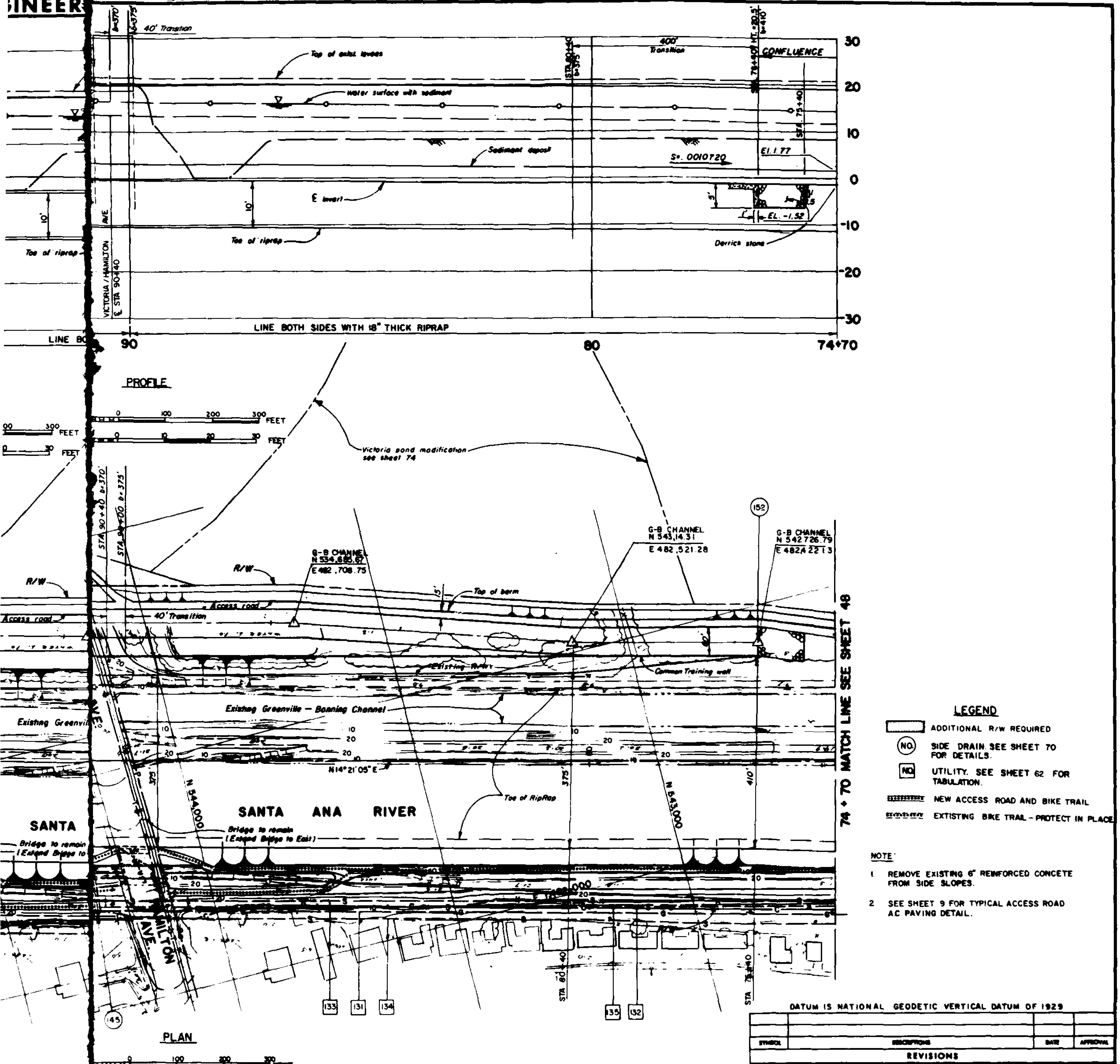
VALUE E



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SA

VALUE ENGINEERING PAYS



HYDRAULIC ELEMENTS

STA.₁	TO STA.₂	SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030 *				RIPRAP ** THICKNESS	
							D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}	DRY	WET
72+90	76+40	VARIES	.000808	.001072	VARIES	VARIES	13.3	8.0	13.0	8.5	18"	27"
76+40	80+40	TRANS	.000808	.001072	46000	VARIES	12.9	8.6	12.9	8.8	18"	27"
80+40	90+00	375 TRAP	.000808	.001072	46000	7.5	12.9	8.8	13.0	8.7	18"	27"
90+00	90+40	TRANS	.000808	.001072	46000	VARIES	13.0	8.7	13.2	8.7	15"	24"
90+40	104+00	370 TRAP	.000808	.001072	46000	7.5	13.2	8.7	13.3	8.4	15"	24"
104+00	104+50	TRANS	.000808	.001072	46000	VARIES	13.3	8.4	13.2	8.6	15"	24"

* DEPTHS AND VELOCITIES ARE BASED ON WITH-SEDIMENT CONDITIONS
** WET CONDITION IS ASSUMED AT ELEV. 0.0' M.S.L. AND BELOW
D_A AND V_A - DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D. VILPPU

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 74+70 TO STA.104+50

DISTRICT FILE NO.

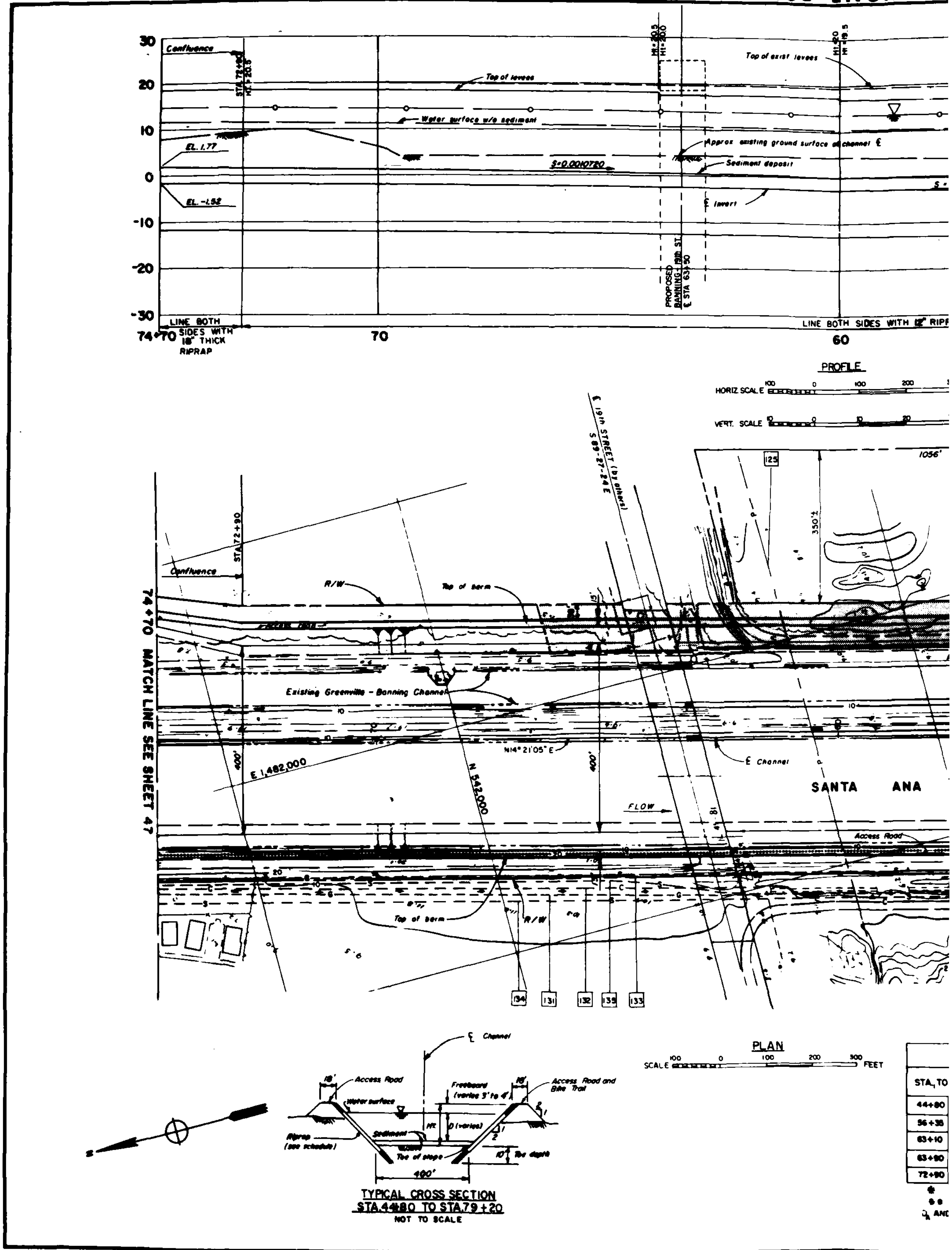
SHEET 47 OF 105 SHEETS

PLATE 30

SAFETY PAYS

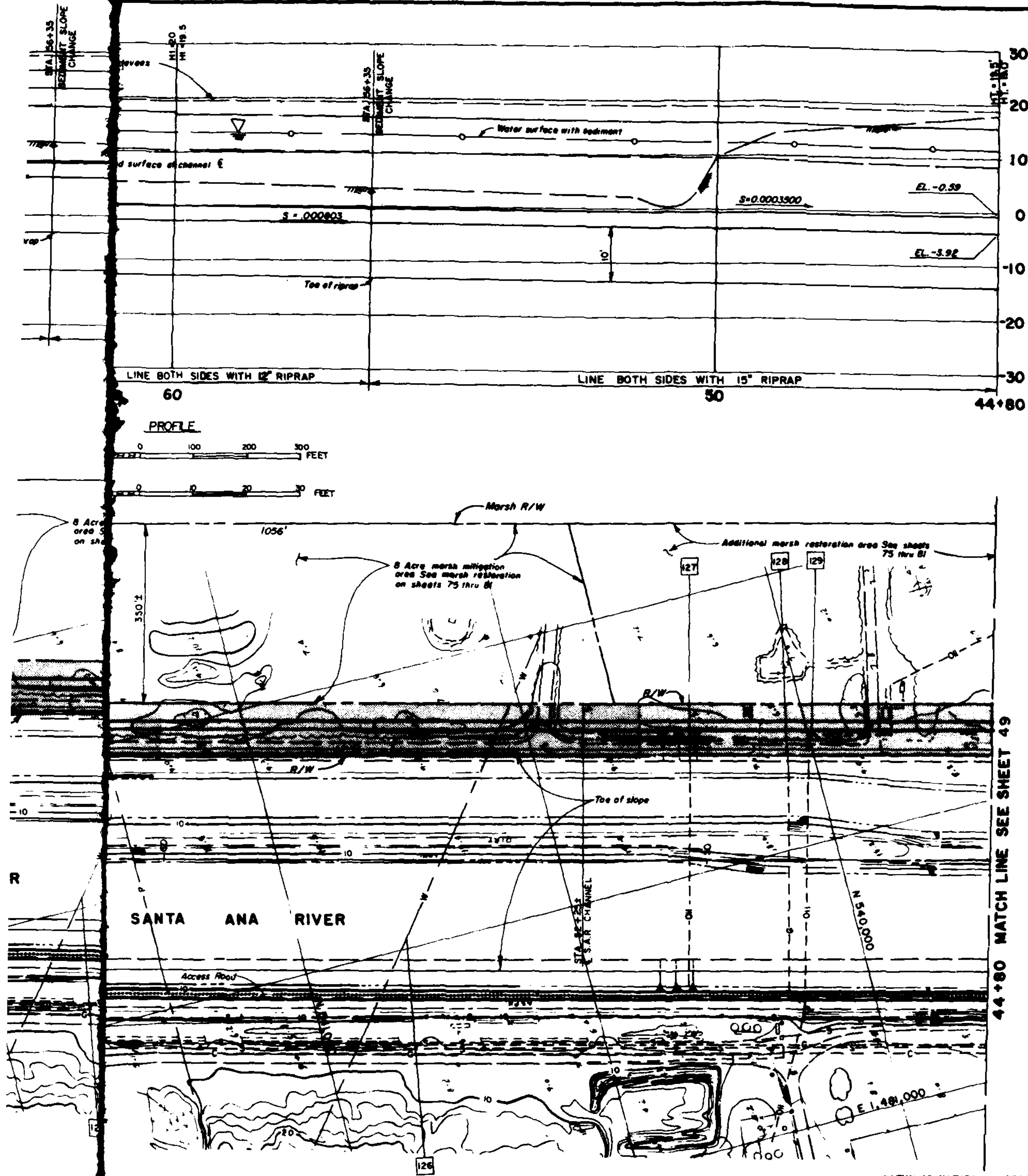
2

VALUE ENGINEER



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY P



LEGEND

- ADDITIONAL R/W REQUIRED
- NEW ACCESS ROAD AND BIKE TRAIL
- UTILITY SEE SHEET 62 FOR TABULATION

NOTE:

1. REMOVE EXISTING 6" REINFORCED CONCRETE FROM SIDE SLOPES.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

HYDRAULIC ELEMENTS

STA_1	TO STA_2	SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030 * D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}	RIPRAP THICKNESS ** DRY	WET
44+80	56+35	400' TRAP	.000803	.000350	47000	7.3	12.3	8.8	13.3	8.0	15"	24"
56+35	63+10	400' TRAP	.000803	.001072	47000	7.3	13.3	8.0	13.4	8.0	12"	18"
63+10	63+90	400' TRAP	.000803	.001072	47000	7.2	13.4	8.0	13.4	7.9	12"	18"
63+90	72+90	400' TRAP	.000803	.001072	47000	7.2	13.4	7.9	13.3	8.0	12"	18"
72+90	76+40	VARIES	.000803	.001072	VARIES	VARIES	13.3	8.0	13.0	8.5	1'	2'

* DEPTHS AND VELOCITIES ARE BASED ON WITH - SEDIMENT CONDITIONS

** WET CONDITION IS ASSUMED AT ELEV 0.0 MSL AND BELOW

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY:

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 44 +80 TO STA 74 + 70

SUBMITTED BY:

DATE APPROVED:

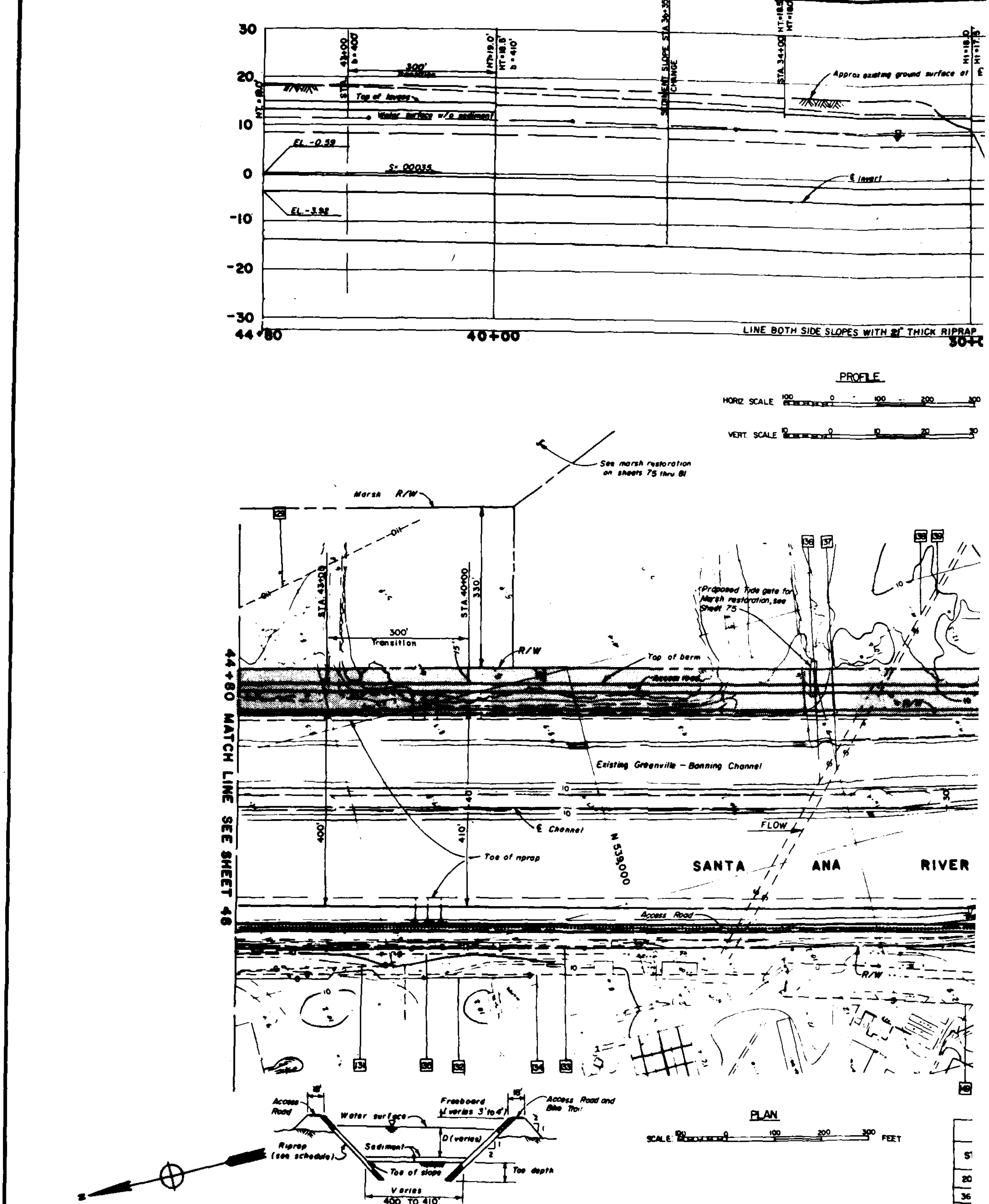
DISTRICT FILE NO.

SHEET 48 OF 105 SHEETS

PLATE 84

VALUE ENGINEER

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

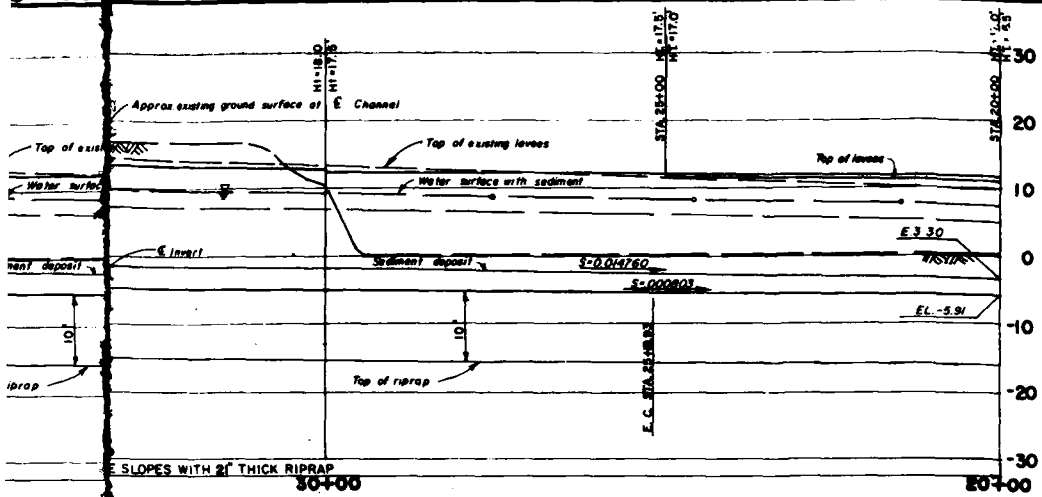


TYPICAL CROSS SECTION

STA. 21+00 TO STA. 44+80

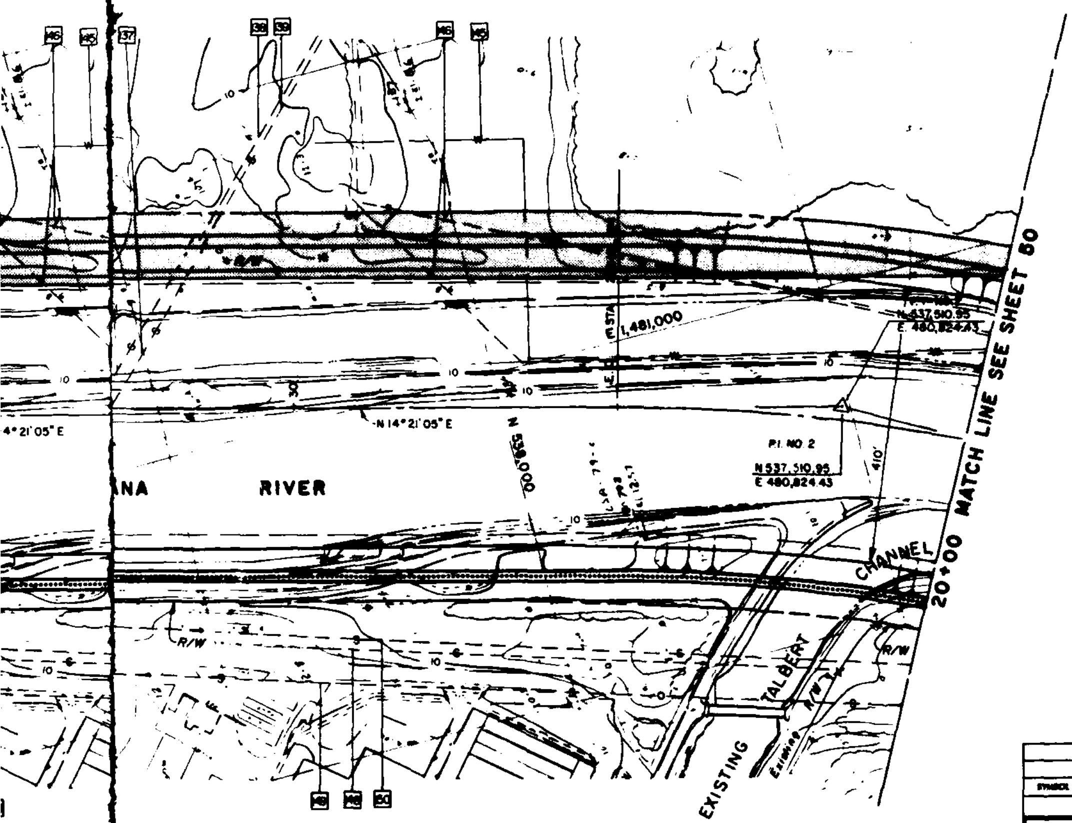
NOT TO SCALE

SAFETY



PROFILE

P.I. NO. 2
℄ CURVE DATA
Δ = 13° 49' 37"
R = 2,730'
T = 331.02'
L = 658.82'



NOTE:

1. REMOVE EXISTING 6" REINFORCED CONCRETE FROM SIDE SLOPES. SEE SHEET 66 FOR REMOVAL AT THE MOUTH.
2. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

LEGEND

- ADDITIONAL R/W REQUIRED
- NEW ACCESS ROAD AND BIKE TRAIL
- UTILITY. SEE SHEET 62 FOR TABULATION

HYDRAULIC ELEMENTS

STA. TO STA.		SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030 *				RIPRAP THICKNESS **	
							DA	VA	DA	VA	DRY	WET
20+00	36+36	410 TRAP	.000803	.001476	47000	7.7	10.9	9.8	11.2	9.5	21"	33"
36+36	40+00	410 TRAP	.000803	.00036	47000	7.7	11.2	9.5	11.8	9.0	21"	33"
40+00	43+00	TRANS.	.000803	.00036	47000	VARIES	11.6	9.0	12.1	8.9	21"	33"
43+00	44+80	400 TRAP	.000803	.00086	47000	7.7	12.1	8.9	12.3	8.8	21"	33"

* DEPTH AND VELOCITIES ARE BASED ON WITH-SEDIMENT CONDITIONS

** WET CONDITION IS ASSUMED AT ELEV. 0.0 MSL AND BELOW

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

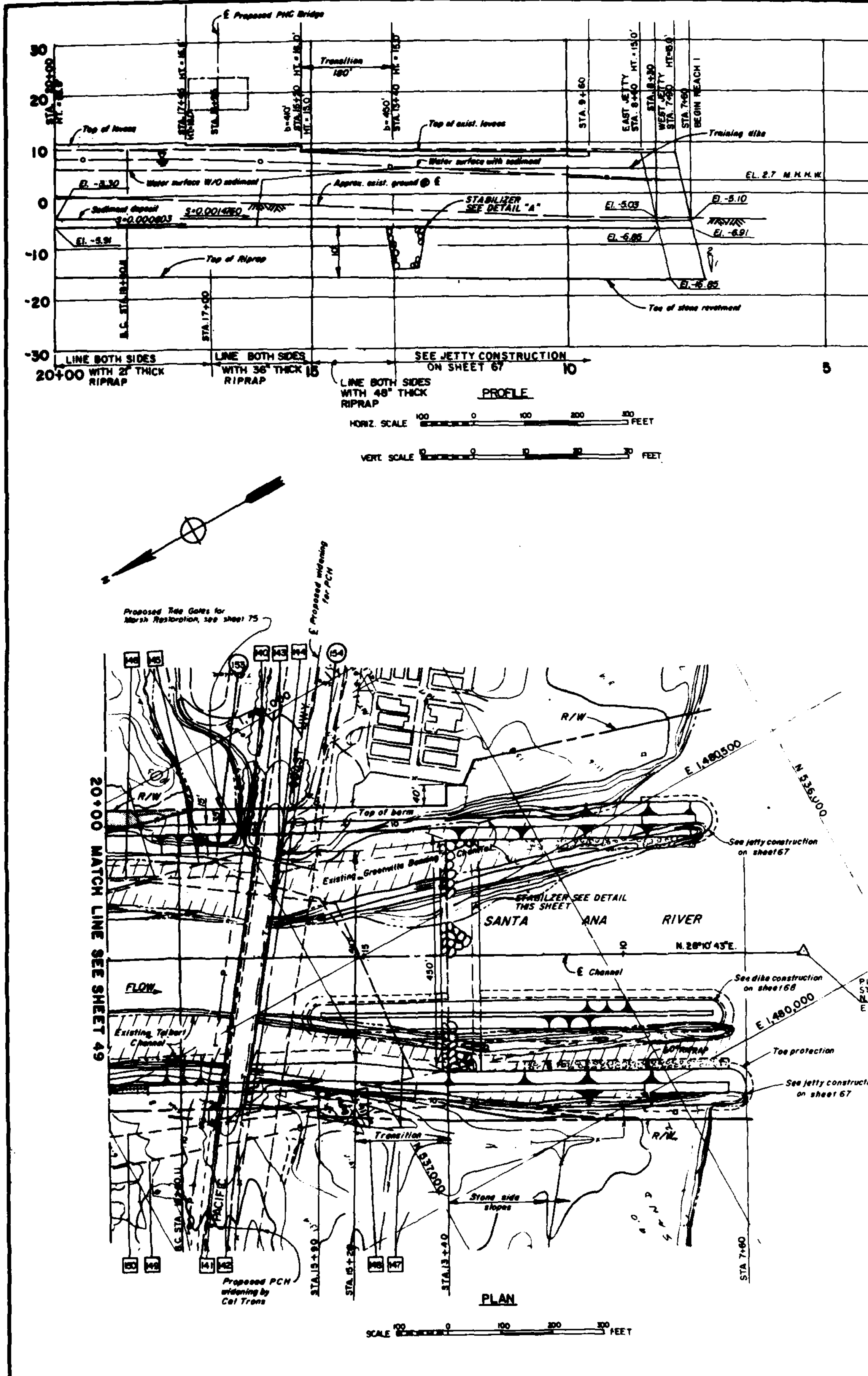
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 20+00 TO STA. 44+80

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 40 OF 105 SHEETS

PLATE 92

ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING

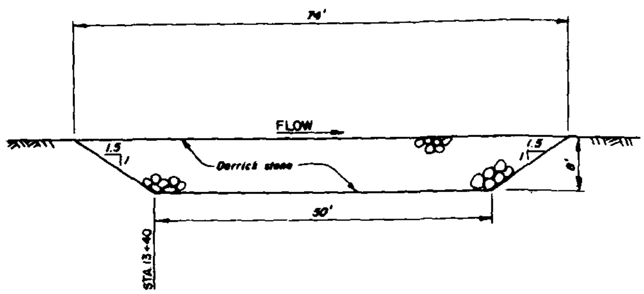


NOTE:
1. SEE SHEET 66 FOR REMOVAL WO[RK] AT THE MOUTH.
2. EXISTING SAND PLUG DOWNSTREAM [OF] RECOMMENDED STABILIZER TO RE[MAIN] EXCEPT FOR THAT REQUIRED IN A[REA] OF JETTY REMOVAL AND CONSTR[UCTION]

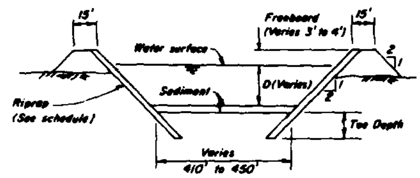
LEGEND

- ADDITIONAL R/W REQU[IRED]
- (NO.) UTILITY SEE SHEET 62 F[OR]
- (NO.) SIDE DRAIN SEE SHEET 7[…]
- NEW ACCESS RD. AND BI[…]

E ENGINEERING PAYS



DETAIL "A"
SECTION THRU STABILIZER
NOT TO SCALE

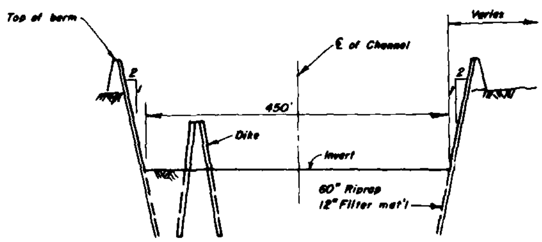


TYPICAL CROSS SECTION
STA. 13+40 TO STA. 20+00
NOT TO SCALE

NOTE:
1. SEE SHEET 66 FOR REMOVAL WORK AT THE MOUTH.
2. EXISTING SAND PLUG DOWNSTREAM OF RECOMMENDED STABILIZER TO REMAIN, EXCEPT FOR THAT REQUIRED IN AREAS OF JETTY REMOVAL AND CONSTRUCTION.

LEGEND
- ADDITIONAL R/W REQUIRED
- NO. UTILITY SEE SHEET 62 FOR TABULATION
- (NO.) SIDE DRAIN SEE SHEET 70 FOR DETAILS
- NEW ACCESS RD. AND BIKE TRAIL

NO 1
A 61+50 13
536,152.59
480,096.74



TYPICAL X-SECTION
STA. 8+30 TO STA. 12+66
NOT TO SCALE

HYDRAULIC ELEMENTS											**	
STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	SEDIMENT SLOPE	Q (cfs)	Dc (ft)	n = .030 *				RIPRAP THICKNESS	
							D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}	DRY	WET
8+30	13+40	450 TRAP	.000803	.0014760	47000	7.3	7.7	14.1	10.0	10.8	XXX	XXX
13+40	15+20	TRANSITION	.000803	.0014760	47000	–	10.0	10.8	10.0	11.6	48"	72"
15+20	17+00	410 TRAP	.000803	.0014760	47000	7.7	10.0	11.6	10.4	11.1	36"	54"
17+00	17+50	410 TRAP	.000803	.0014760	47000	7.7	10.4	11.1	10.8	10.0	21"	33"
17+50	18+00	410 TRAP	.000803	.0014760	47000	7.7	10.8	10.0	10.8	10.0	21"	33"
18+00	20+00	410 TRAP	.000803	.0014760	47000	7.7	10.8	10.0	10.9	9.8	21"	33"

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT
* DEPTHS AND VELOCITIES ARE BASED ON WITH – SEDIMENT CONDITIONS
** WET CONDITION IS ASSUMED AT ELEV. 0.0' M.S.L. AND BELOW
*** SEE JETTY PLANS SHEET 67

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
PLAN AND PROFILE
STA. 7+60 TO STA 20+00

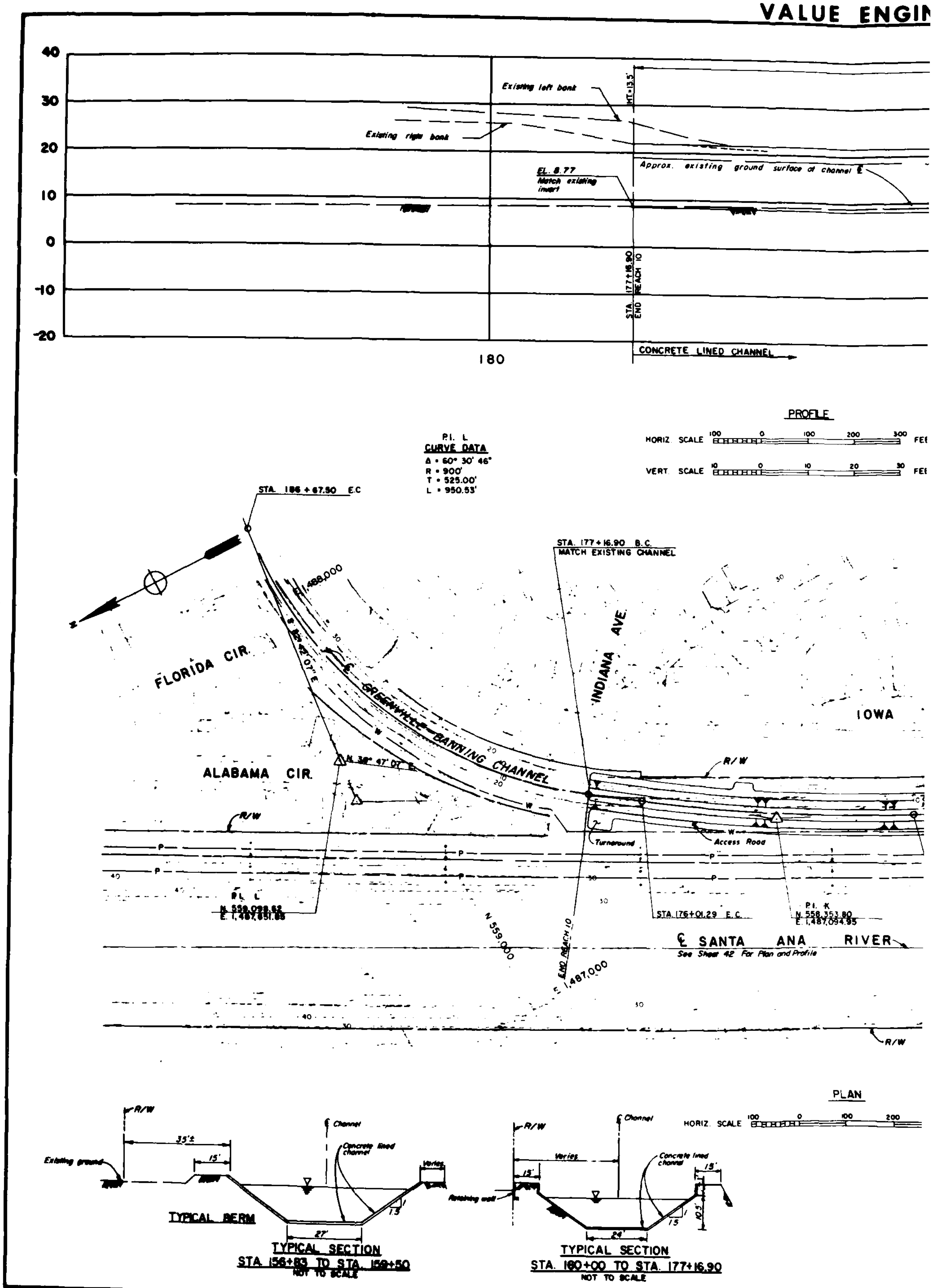
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 80 OF 105 SHEETS
PLATE

SAFETY PAYS

2

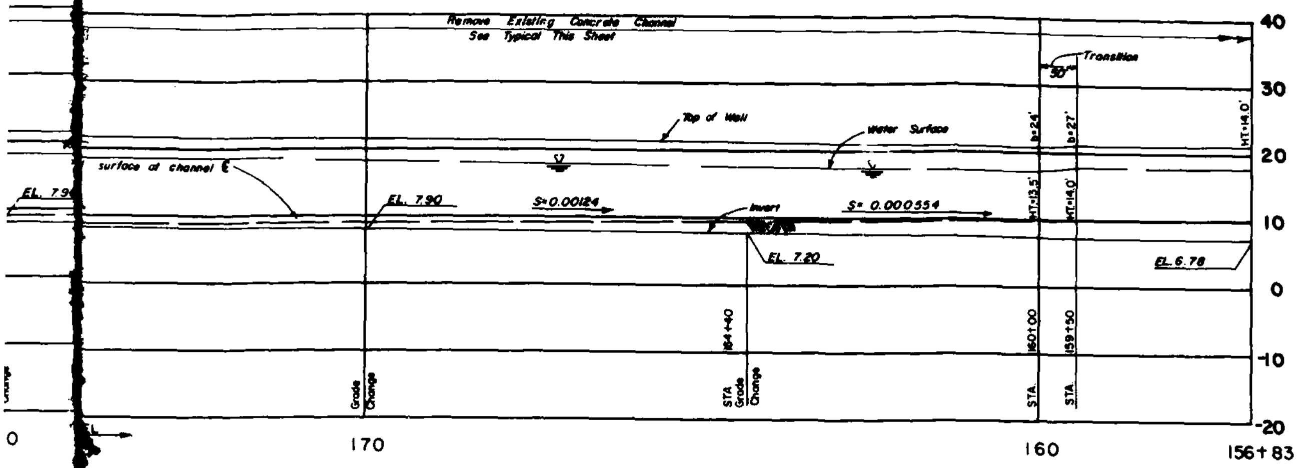
VALUE ENGIN

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

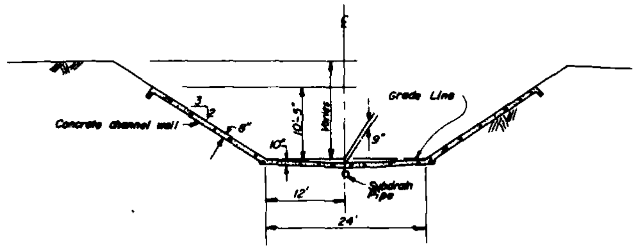


SAFETY

RIN VALUE ENGINEERING PAYS



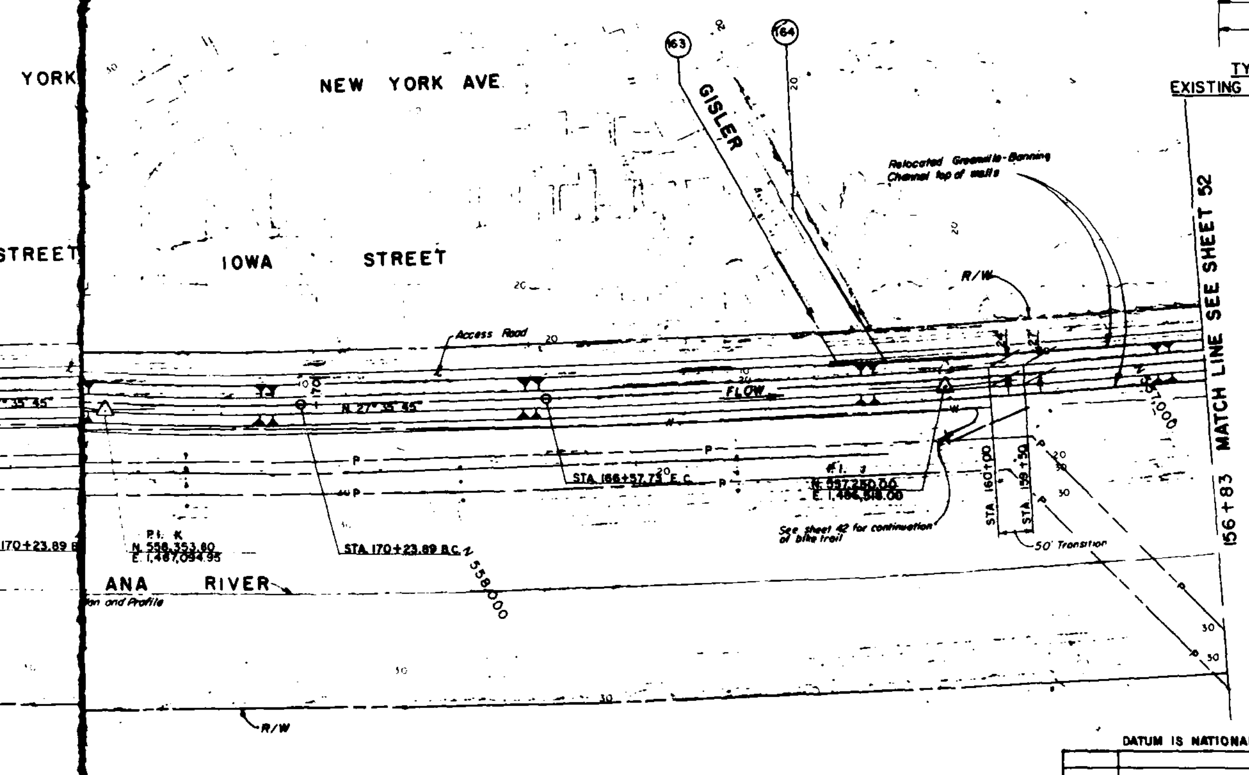
PROFILE



TYPICAL SECTION
EXISTING CONCRETE CHANNEL
NOT TO SCALE

P.I. K
CURVE DATA
Δ = 09° 11' 22"
R = 3,600'
T = 289.32'
L = 577.40'

P.I. J
CURVE DATA
Δ = 03° 45' 17"
R = 18,000'
T = 590.01'
L = 1179.69'



LEGEND

(NO) SIDE DRAIN. SEE SHEET 70 FOR DETAILS.

NOTE:

1. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

PLAN

HYDRAULIC ELEMENTS									
STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	D (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
156+83	159+50	27' TRAP	.000554	5000	8.6	10.9	10.7	10.9	10.6
159+50	160+00	TRANSITION	.000554	5000	VARIES	10.9	10.6	10.4	12.2
160+00	164+40*	COMPOSITE SECTION	.000554	5000	9.1	10.4	12.2	10.8	11.8
164+40	180+00	COMPOSITE SECTION	.00124	5000	9.1	10.8	11.5	10.1	12.7

* INTERSECTION WITH EXISTING CHANNEL INVERT

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: F. Castellanos

CHECKED BY:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

GREENVILLE-BANNING CHANNEL
PLAN AND PROFILE
STA. 156 + 83 TO STA. 177+17

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

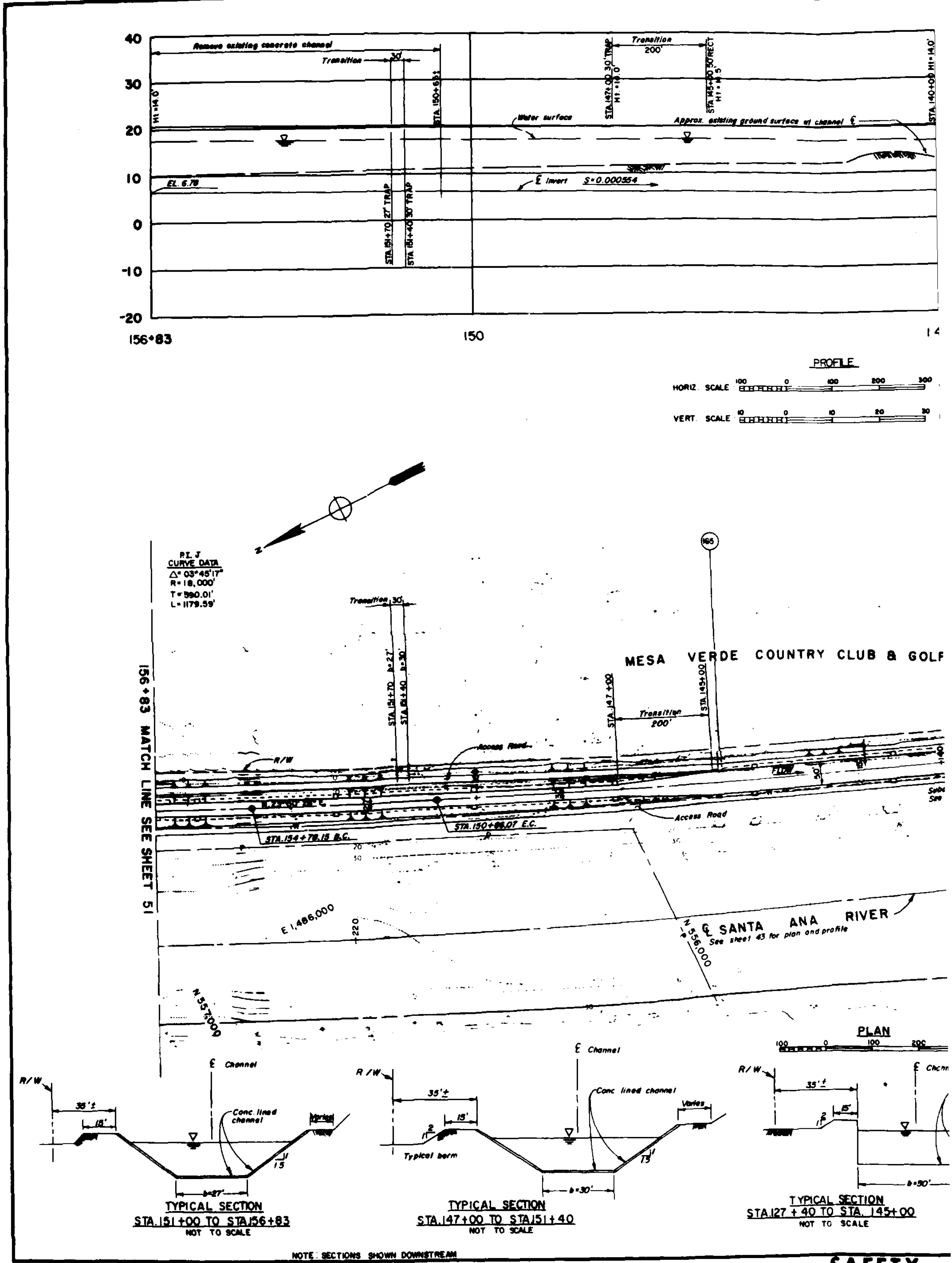
SHEET 51 OF 109 SHEETS

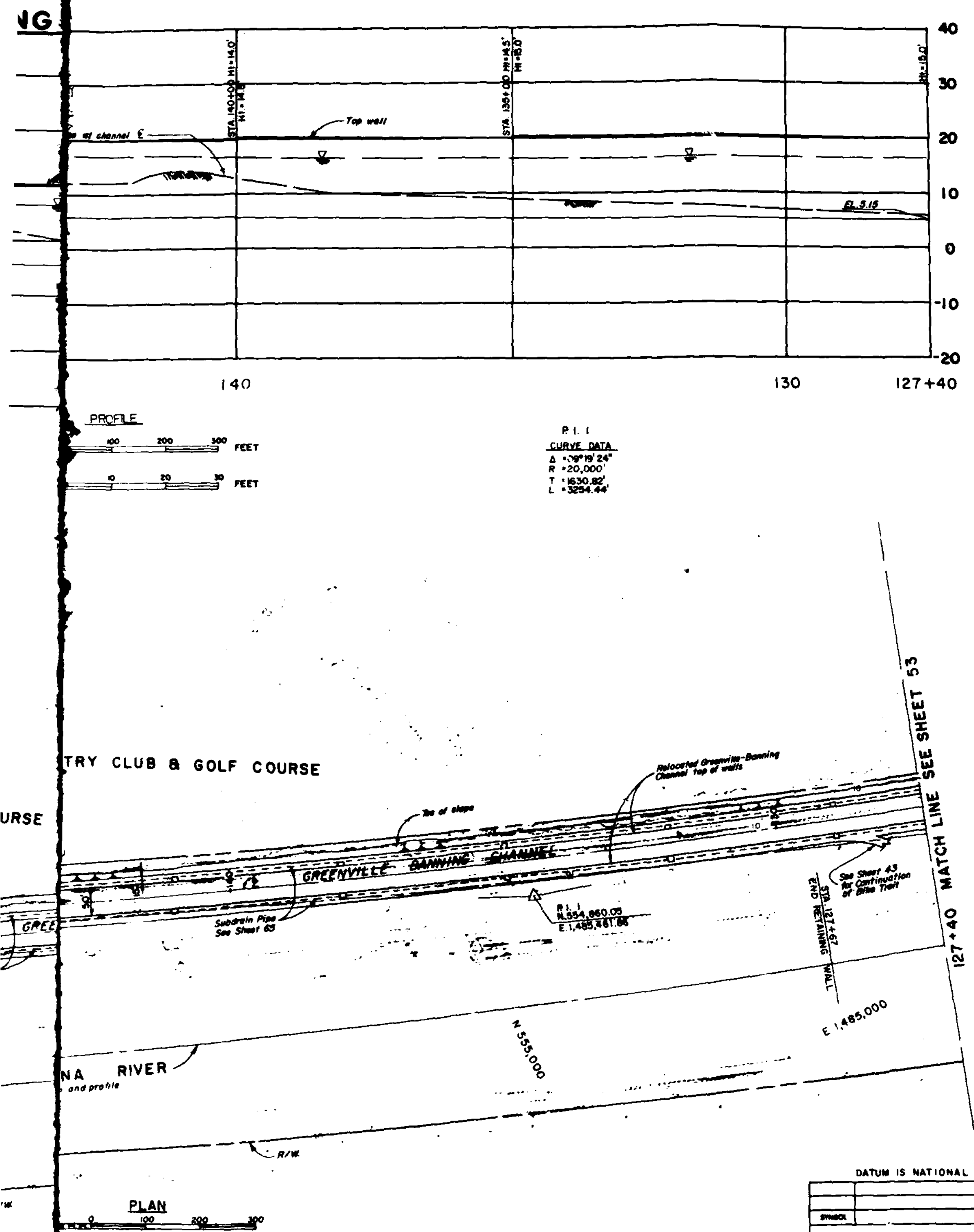
PLATE 54

AYS SAFETY PAYS

2

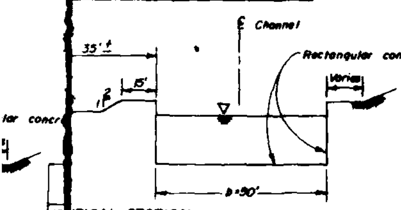
ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING





LEGEND

(NO.) SIDE DRAIN SEE SHEET 70 FOR DETAIL



TYPICAL SECTION
STA. 127+40 TO STA. 145+00
NOT TO SCALE

HYDRAULIC ELEMENTS

STA.$_1$	TO STA.$_2$	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014 D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
127+40	145+00	30' RECT	.000554	5000	6.6	11.4	8.7	11.2	8.9
145+00	147+00	TRANSITION	.000564	5000	VARIES	11.2	8.9	11.0	9.8
147+00	151+40	30' TRAP	.000564	5000	8.3	11.0	9.8	11.0	9.8
151+40	151+70	TRANSITION	.000564	5000	VARIES	11.0	9.8	10.6	10.9
151+70	156+63	27' TRAP	.000554	5000	8.6	10.6	10.9	10.9	10.7

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: D.VILPPU

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

GREENVILLE-BANNING CHANNEL
PLAN AND PROFILE
STA. 127 + 40 TO STA. 156 + 83

SUBMITTED BY:

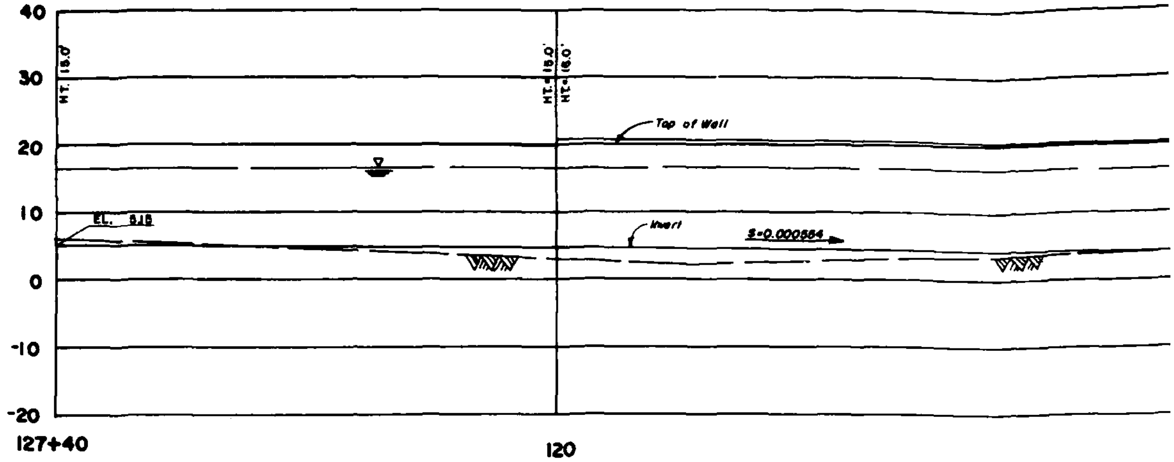
DATE APPROVED:

DISTRICT FILE NO.

SHEET 52 OF 105 SHEETS

PLATE 56

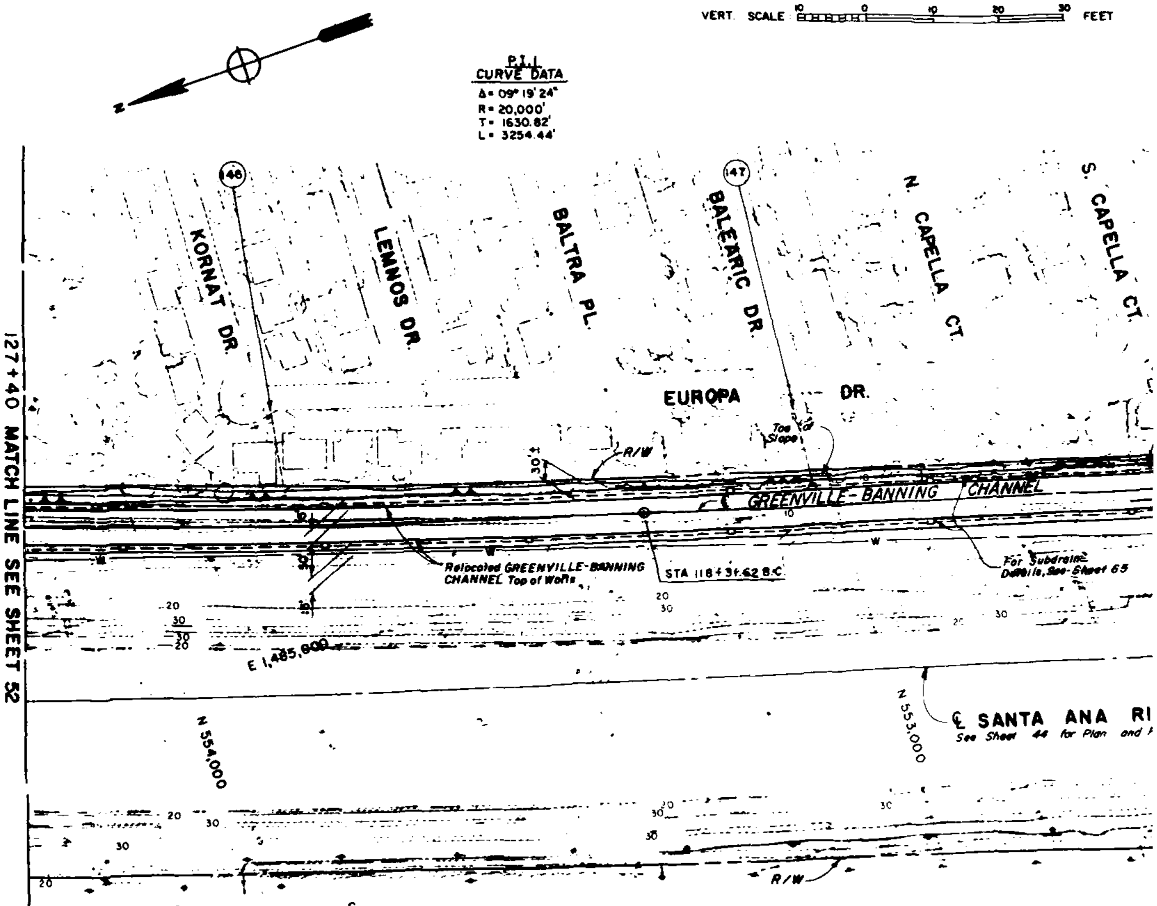
VALUE ENGINEE



PROFILE

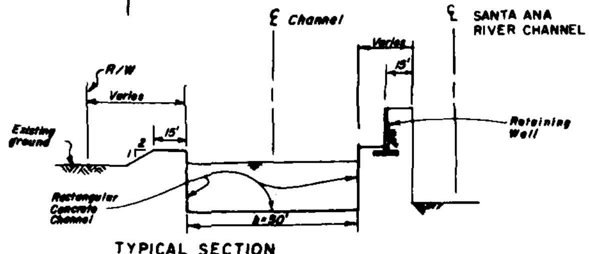
HORIZ. SCALE : 100 0 100 200 300 FEET

VERT. SCALE : 10 0 10 20 30 FEET



PLAN

SCALE : 100 0 100 200 300 FEET

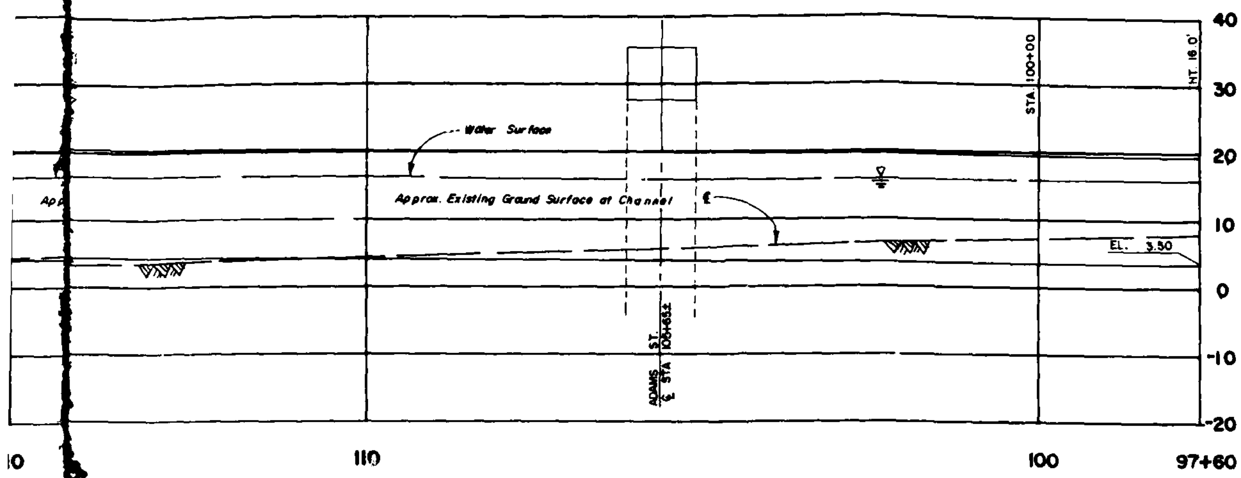


TYPICAL SECTION
STA. 97+60 TO STA. 127+67
NOT TO SCALE

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY

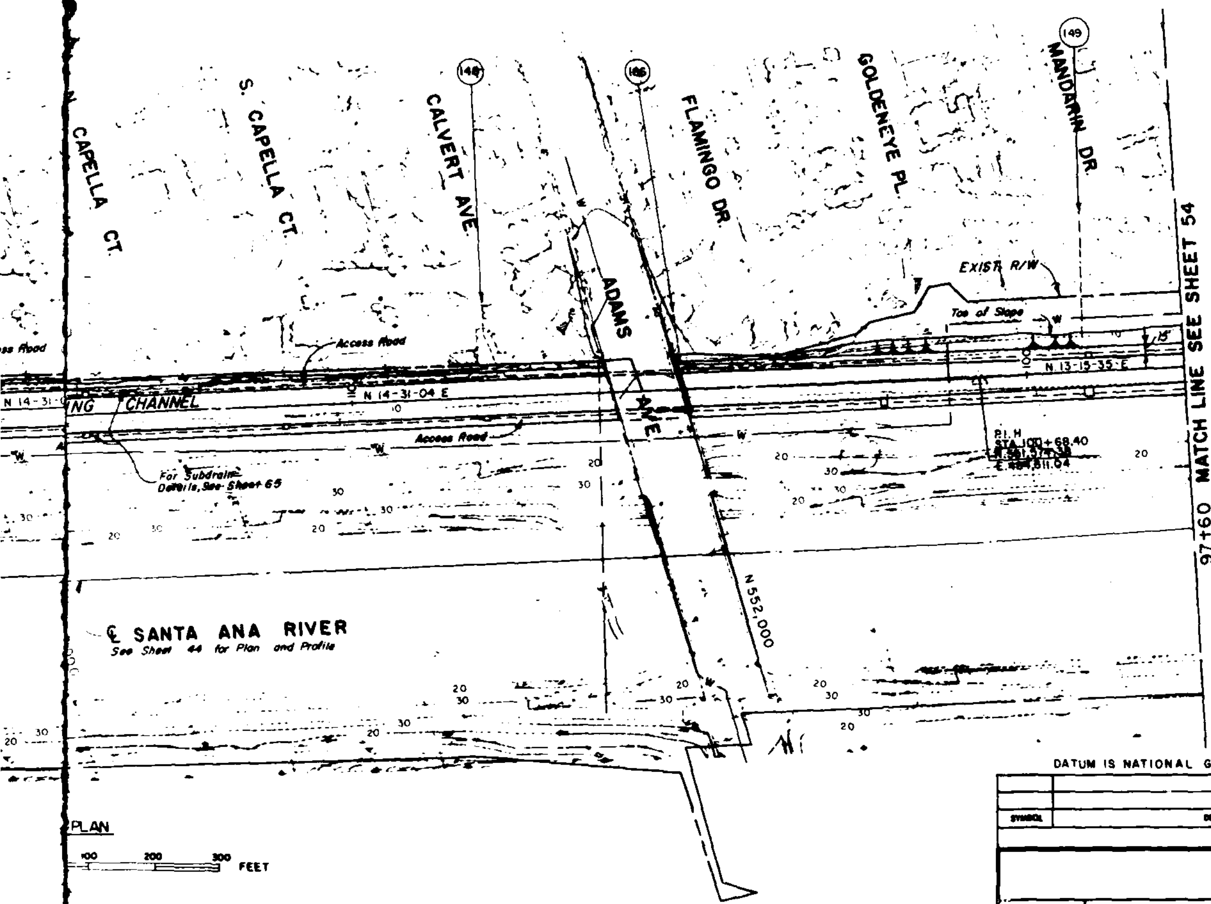
G LUE ENGINEERING PAYS



PROFILE

100 200 300 FEET

10 20 30 FEET



(NO.) SIDE DRAIN. SEE SHEET 70 FOR DETAILS

NOTES:

1. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

PLAN

100 200 300 FEET

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
97+60	127+40	50' RECT	.000584	5000	6.8	12.0	8.3	11.4	8.7

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: ZBA

CHECKED BY:

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

GREENVILLE-BANNING CHANNEL
PLAN AND PROFILE
STA. 97 + 60 TO STA. 127 + 40

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

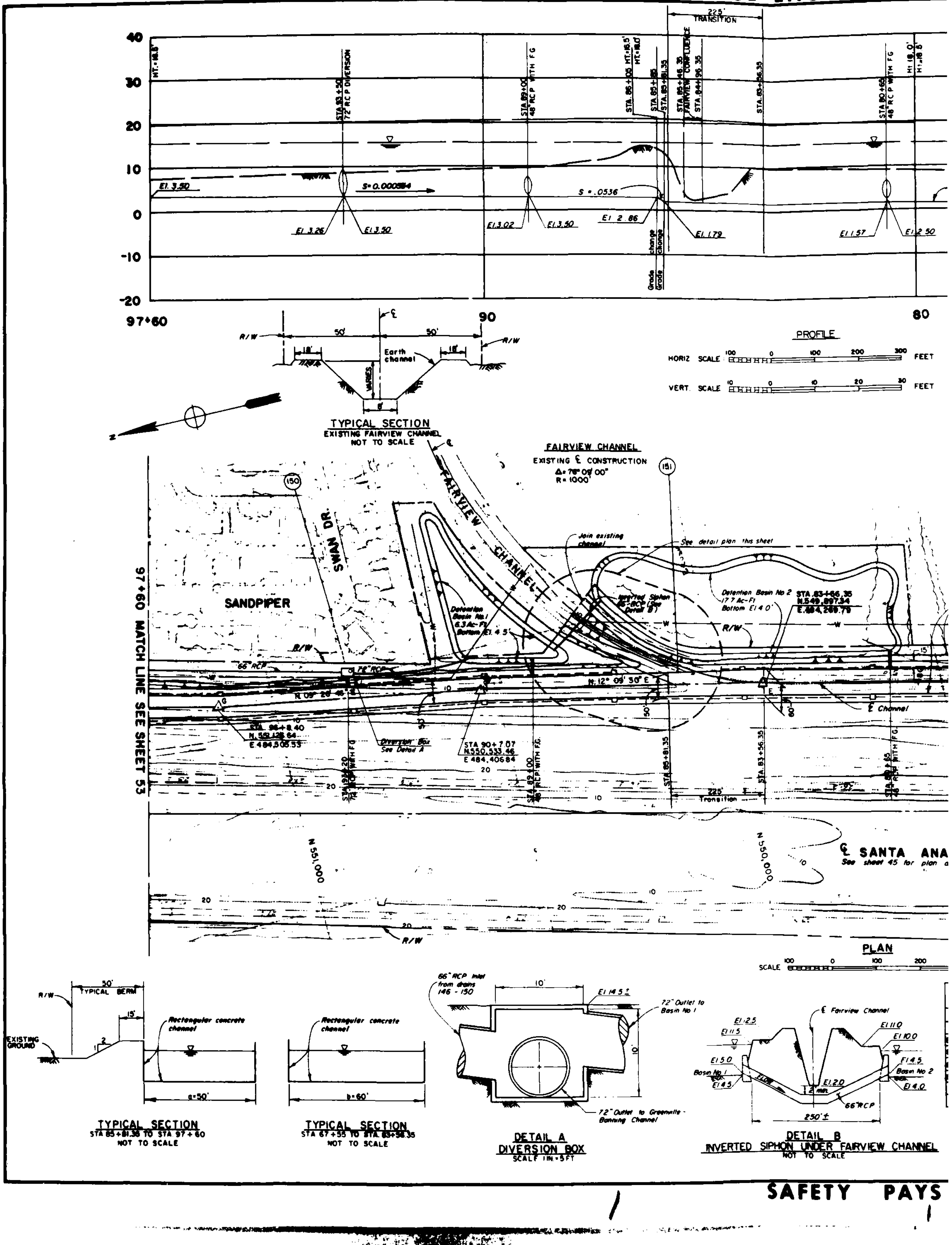
SHEET 53 OF 108 SHEETS

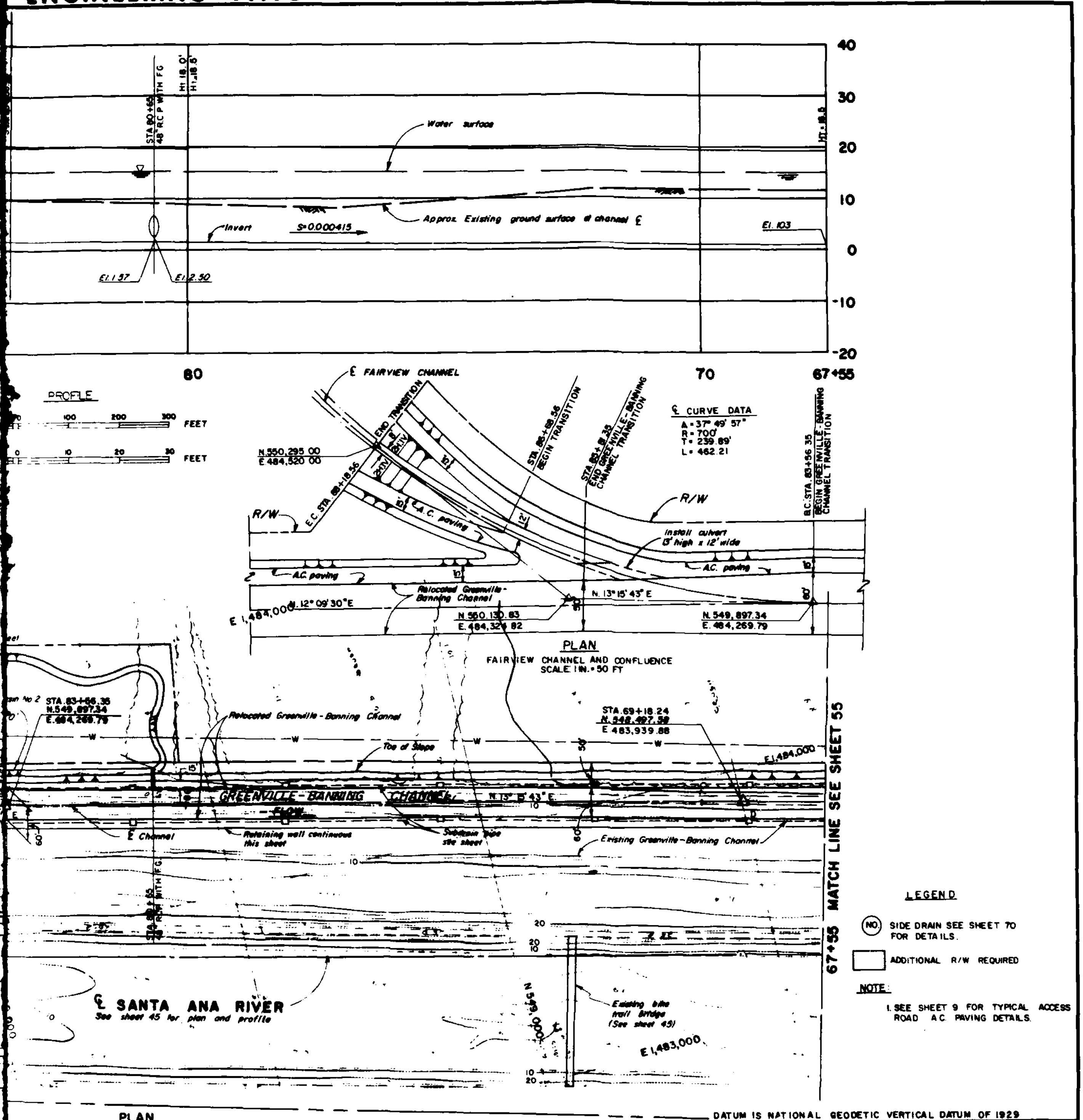
PLATE 56

SAFETY PAYS

2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





LEGEND

(NO) SIDE DRAIN SEE SHEET 70 FOR DETAILS.

ADDITIONAL R/W REQUIRED

NOTE:

1. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

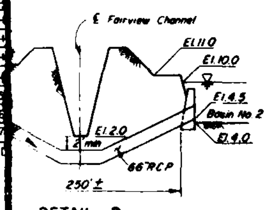
PLAN

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
67+55	80+00	60'RECT	0.000415	5700	6.5	13.8	6.9	13.6	7.0
80+00	83+56.35	60'RECT.	0.000415	5600	6.5	13.6	7.0	13.5	6.9
83+56.35	84+96.35	TRANS.	0.000415	5600	VARIES	13.5	6.9	13.3	7.8
84+96.35	85+46.35	CONFLUENCE	0.000415	VARIES	VARIES	13.3	7.8	13.6	7.0
85+46.35	85+61.35	TRANS.	0.000415	5000	VARIES	13.6	7.0	13.5	7.4
85+61.35	85+85	50'RECT.	0.000584	5000	6.8	13.5	7.4	13.5	7.4
85+85	86+05	50'RECT.	0.0536	5000	6.8	13.5	7.4	12.3	8.2
86+05	97+60	50'RECT.	0.000854	5000	6.8	12.3	8.2	12.0	8.3

D_A AND V_A = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT



DETAIL B
SIPHON UNDER FAIRVIEW CHANNEL
NOT TO SCALE

REVISIONS

SYMBOL | DESCRIPTION | DATE | APPROVAL

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: F. Castellanos

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

GREENVILLE-BANNING CHANNEL
PLAN AND PROFILE
STA. 67+55 TO STA. 97+60

SUBMITTED BY:

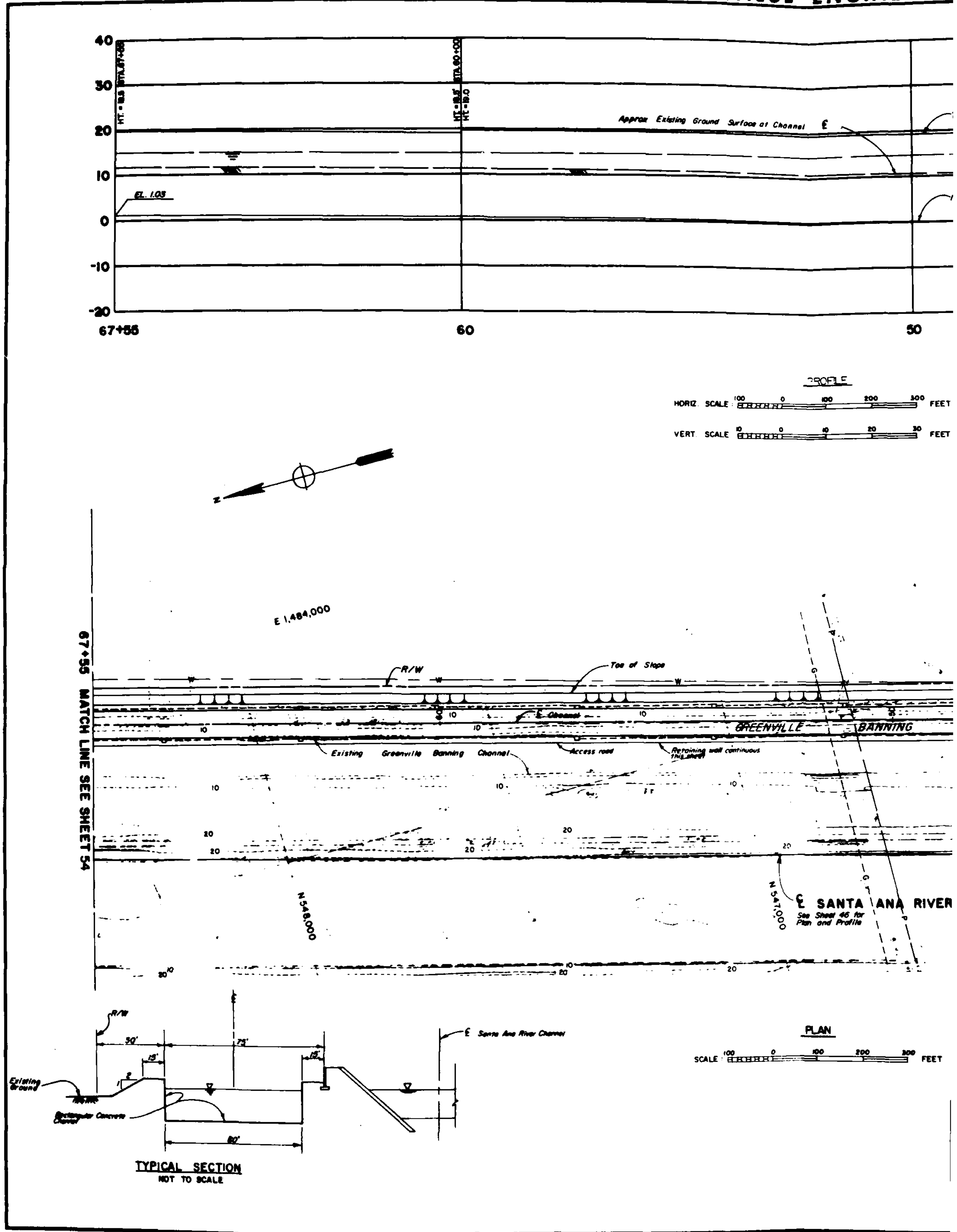
DATE APPROVED:

DISTRICT FILE NO.

SHEET 84 OF 108 SHEETS

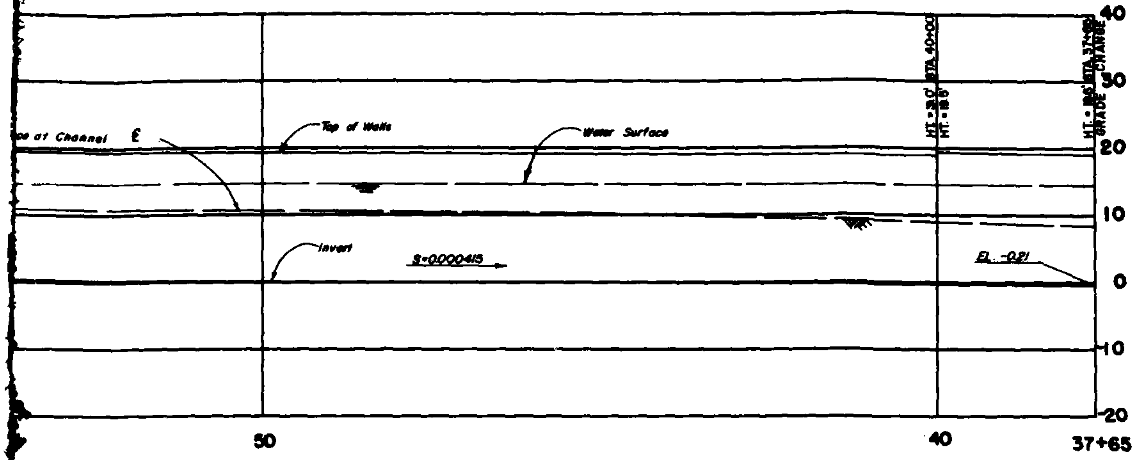
PLATE 57

2

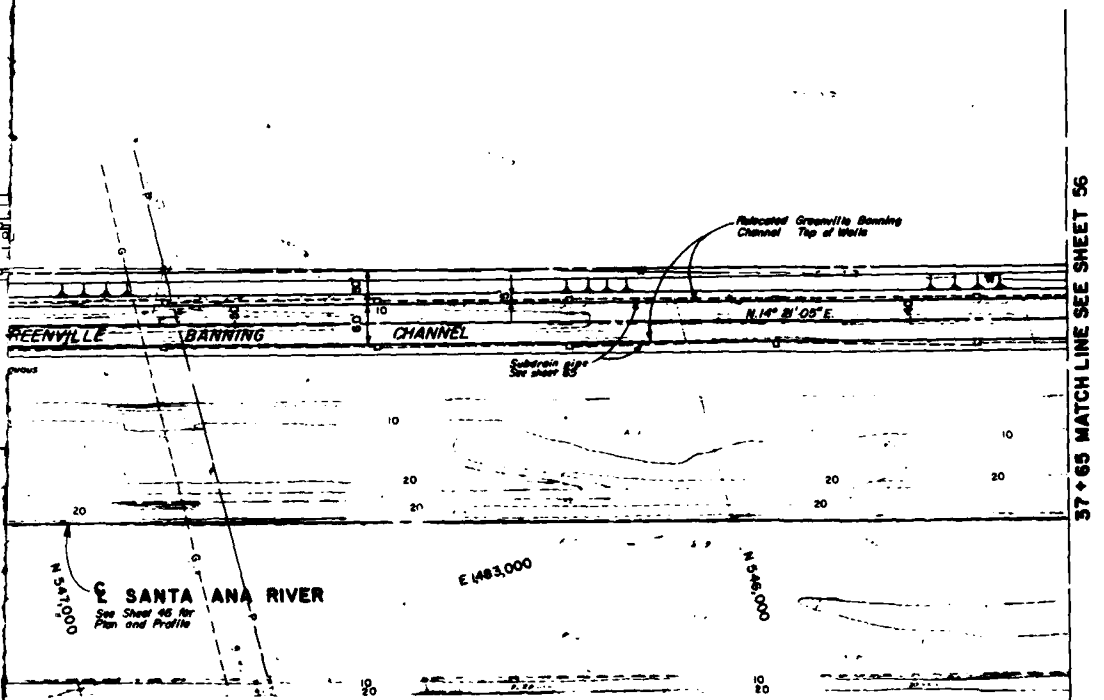


ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

LUE ENGINEERING PAYS



PROFILE



PLAN

NOTE:

1. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

HYDRAULIC ELEMENTS

STA.1	TO STA.2	SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n = .014			
						Da_1	Va_1	Da_2	Va_2
37+65	40+00	60' RECT	.000415	6800 1/	6.6	14.6	6.6	14.5	6.7
40+00	67+55	60' RECT	.000415	5700 1/	6.5	14.5	6.7	13.8	6.9
37+65	40+00	60' RECT	.000415	1000 2/	2.1	15.1	1.1	15.0	1.1
40+00	67+55	60' RECT	.000415	1000 2/	2.1	15.0	1.1	13.9	1.1

1/ Peak discharge in Greenville Banning channel with coincident discharge in Santa Ana river.

2/ Peak discharge in Santa Ana River with coincident discharge in Greenville Banning channel.
D_a AND V_a = DEPTH AND VELOCITY OF FLOW WITH AIR ENTRAINMENT

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: D.VILPPU

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

GREENVILLE - BANNING CHANNEL
PLAN AND PROFILE
STA. 37+65 TO STA. 67+55

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

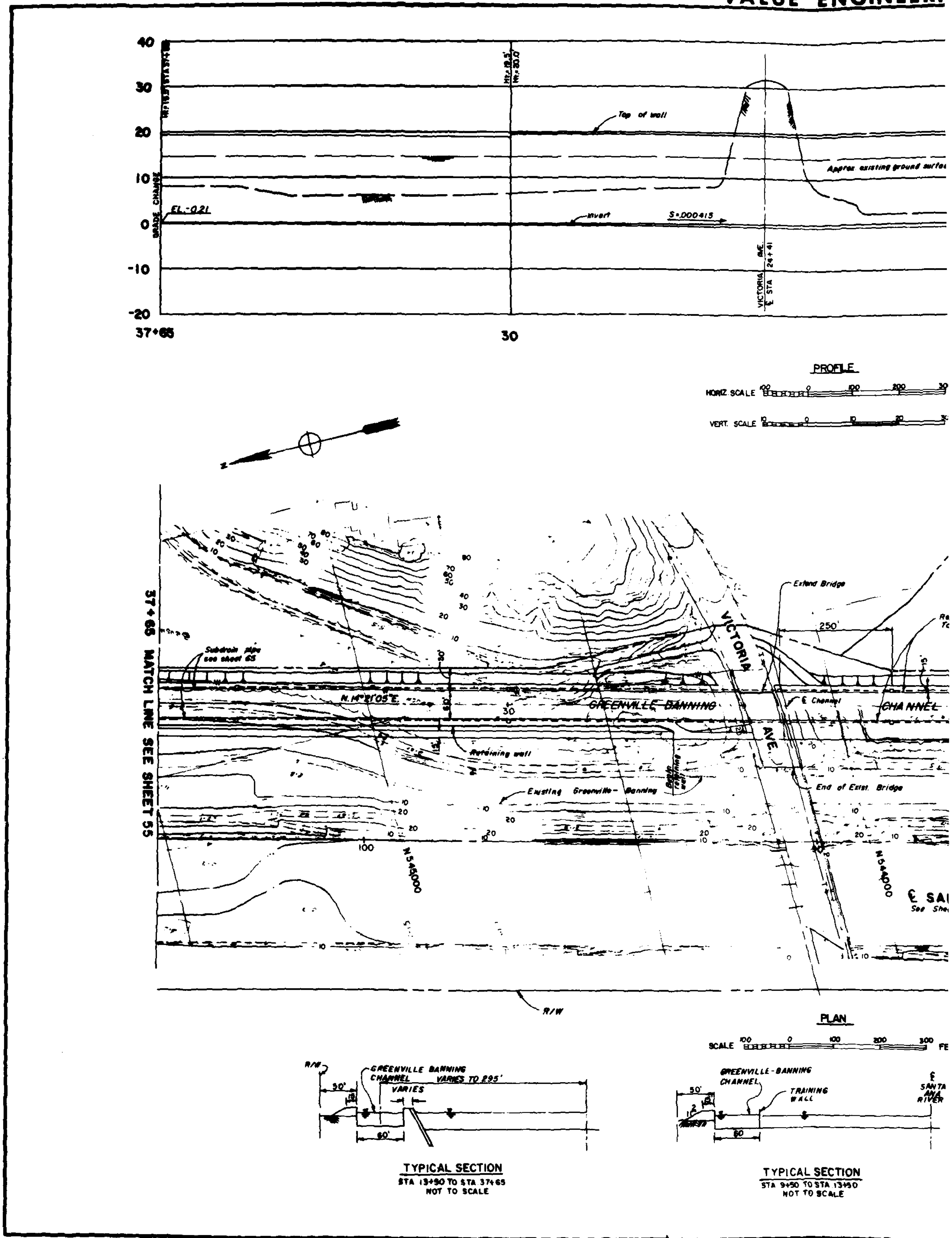
SHEET 55 OF 105 SHEETS

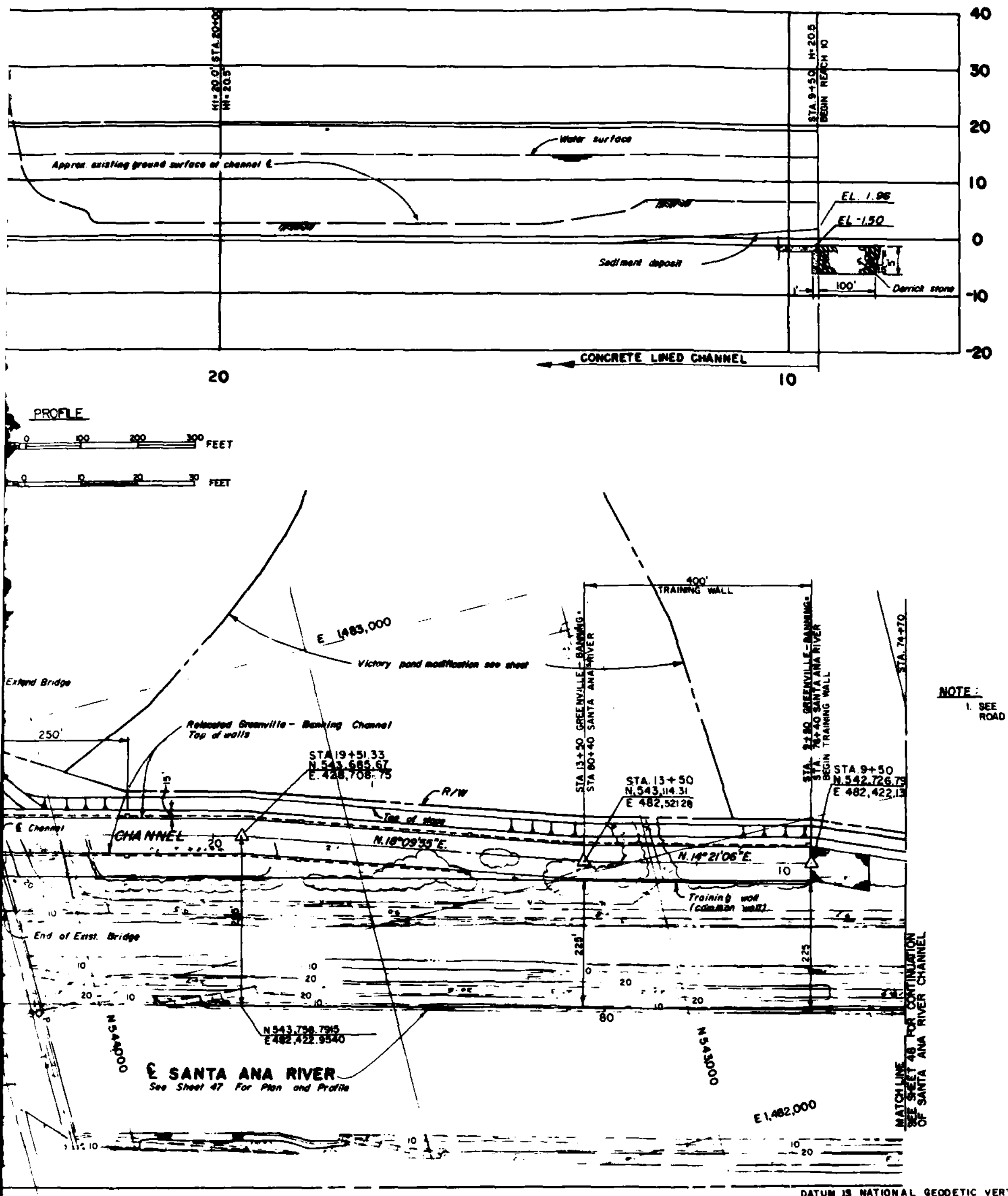
PLATE 58

SAFETY PAYS

1

2


40
30
20
10
0
-10
-20
37+65
30
EL.-0.21
GRADE CHANGE
Top of wall
Approx. existing ground surface
Invert
S=.000415
VICTORIA AVE.
℄ STA 24+41
PROFILE
HORIZ. SCALE
VERT. SCALE
37+65 MATCH LINE SEE SHEET 55
Subdrain pipe see sheet 65
Extend Bridge
250'
VICTORIA
AVE.
N.14°21'05"E.
GREENVILLE BANNING
CHANNEL
℄ Channel
Retaining wall
Existing Greenville- Banning
End of Exist. Bridge
N545000
N544000
℄ SA
R/W
PLAN
SCALE
GREENVILLE BANNING CHANNEL
VARIES TO 295'
VARIES
50'
60'
TYPICAL SECTION
STA 13+90 TO STA 37+65
NOT TO SCALE
GREENVILLE-BANNING CHANNEL
TRAINING WALL
SANTA ANA RIVER
TYPICAL SECTION
STA 9+90 TO STA 13+90
NOT TO SCALE
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



NOTE :
1. SEE SHEET 9 FOR TYPICAL ACCESS ROAD A.C. PAVING DETAILS.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

PLAN

0 100 200 300 FEET

...NING
...TRAINING
...ALL

℄ SANTA ANA RIVER

...AL SECTION
...D TO STA 13+50
...T TO SCALE

HYDRAULIC ELEMENTS

STA.₁ TO STA.₂		SECTION	DESIGN SLOPE	Q (cfs)	Dc (ft)	n=.014			
						D_{A_1}	V_{A_1}	D_{A_2}	V_{A_2}
9+50	37+65	60' Rect	.000415	5800 1/	6.6	11.2	8.6	14.6	6.6
9+50	37+65	60' Rect	.000415	1000 2/	2.1	13.0	1.3	15.0	1.1

D_A AND V_A = DEPTH OF VELOCITY OF FLOW WITH AIR ENTRAINMENT

1/ PEAK DISCHARGE IN GREENVILLE-BANNING CHANNEL WITH COINCIDENT DISCHARGE IN SANTA ANA RIVER

2/ PEAK DISCHARGE IN SANTA ANA RIVER WITH COINCIDENT DISCHARGE IN GREENVILLE BANNING CHANNEL

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

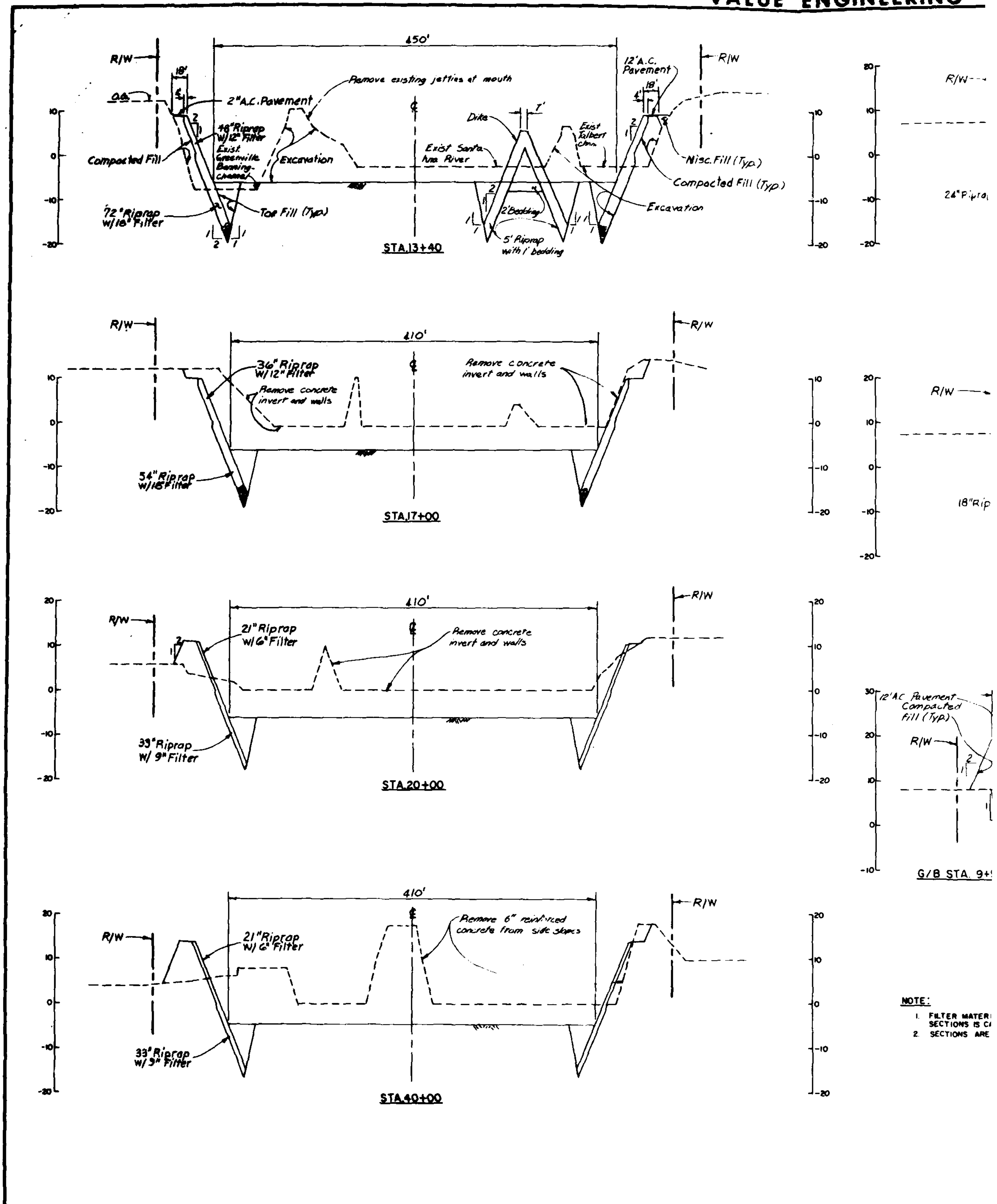
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

GREENVILLE-BANNING CHANNEL
PLAN AND PROFILE
STA. 9+50 TO STA. 37+65

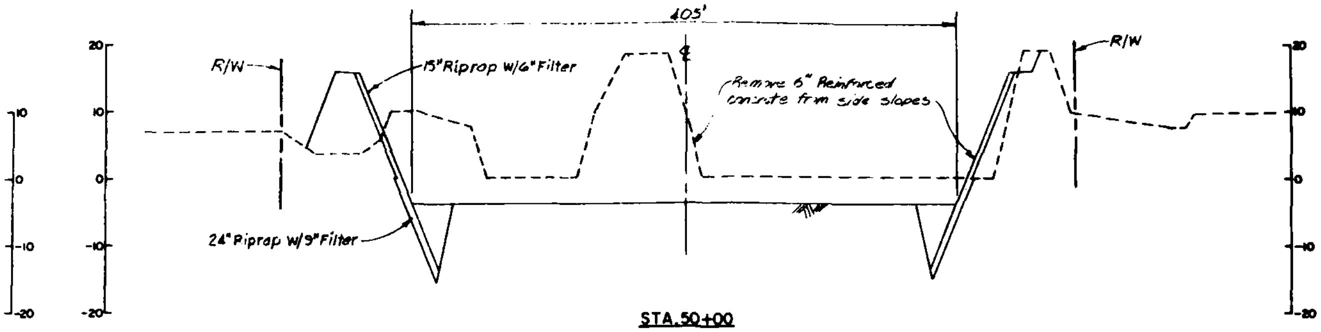
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 96 OF 105 SHEETS
PLATE 89

1

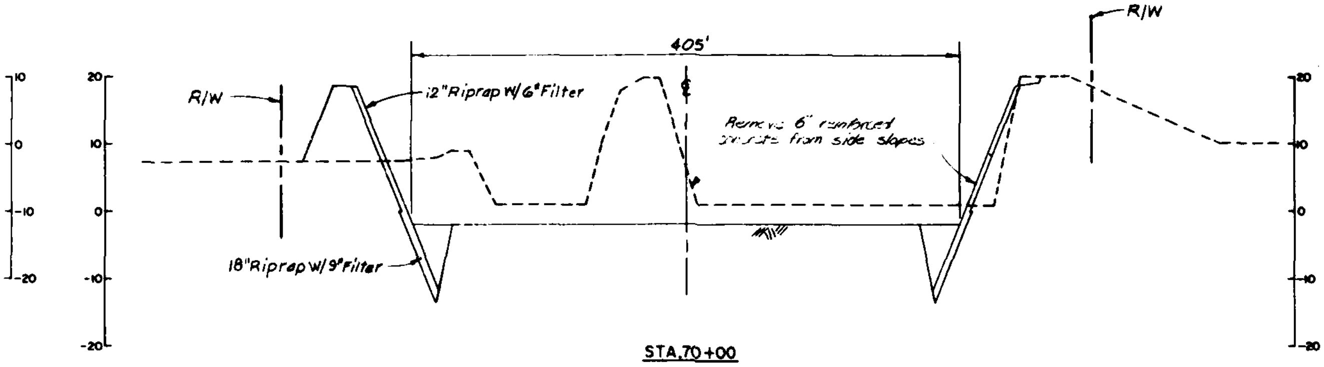
2



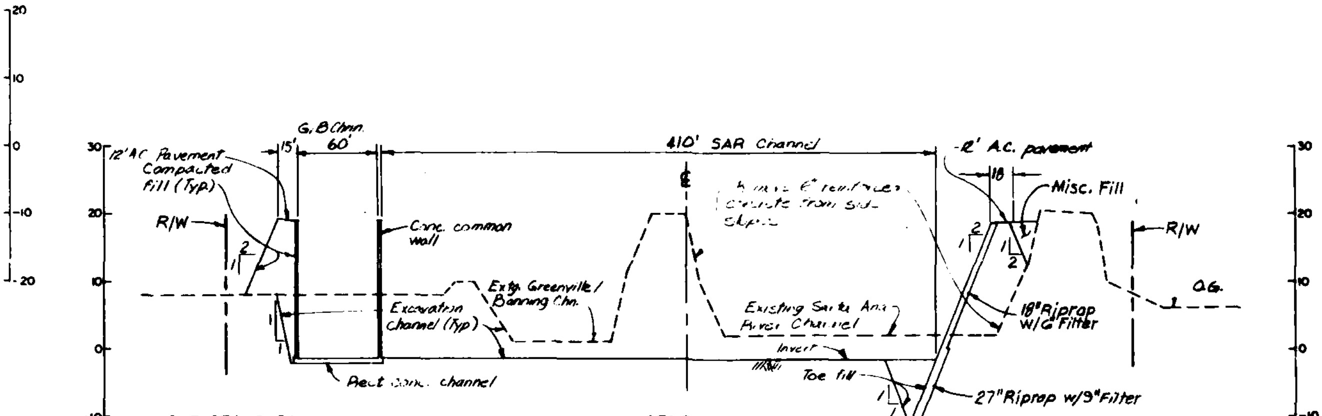
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



STA.50+00



STA.70+00



G/B STA. 9+50±

STA.76+40

NOTE:

1. FILTER MATERIAL FOR TRAPEZOIDAL CHANNEL SECTIONS IS CALLED OUT BUT NOT SHOWN.
2. SECTIONS ARE VIEWED LOOKING DOWNSTREAM.

SCALE: 1 IN.=50FT.

HORIZ. SCALE 50 0 50 100 150 FEET

SCALE: 1 IN.=10FT.

VERT. SCALE 10 0 10 20 30 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D.VILPPU

LOWER SANTA ANA RIVER CHANNEL

CROSS SECTIONS

CHECKED BY:

SUBMITTED BY:

DATE APPROVED:

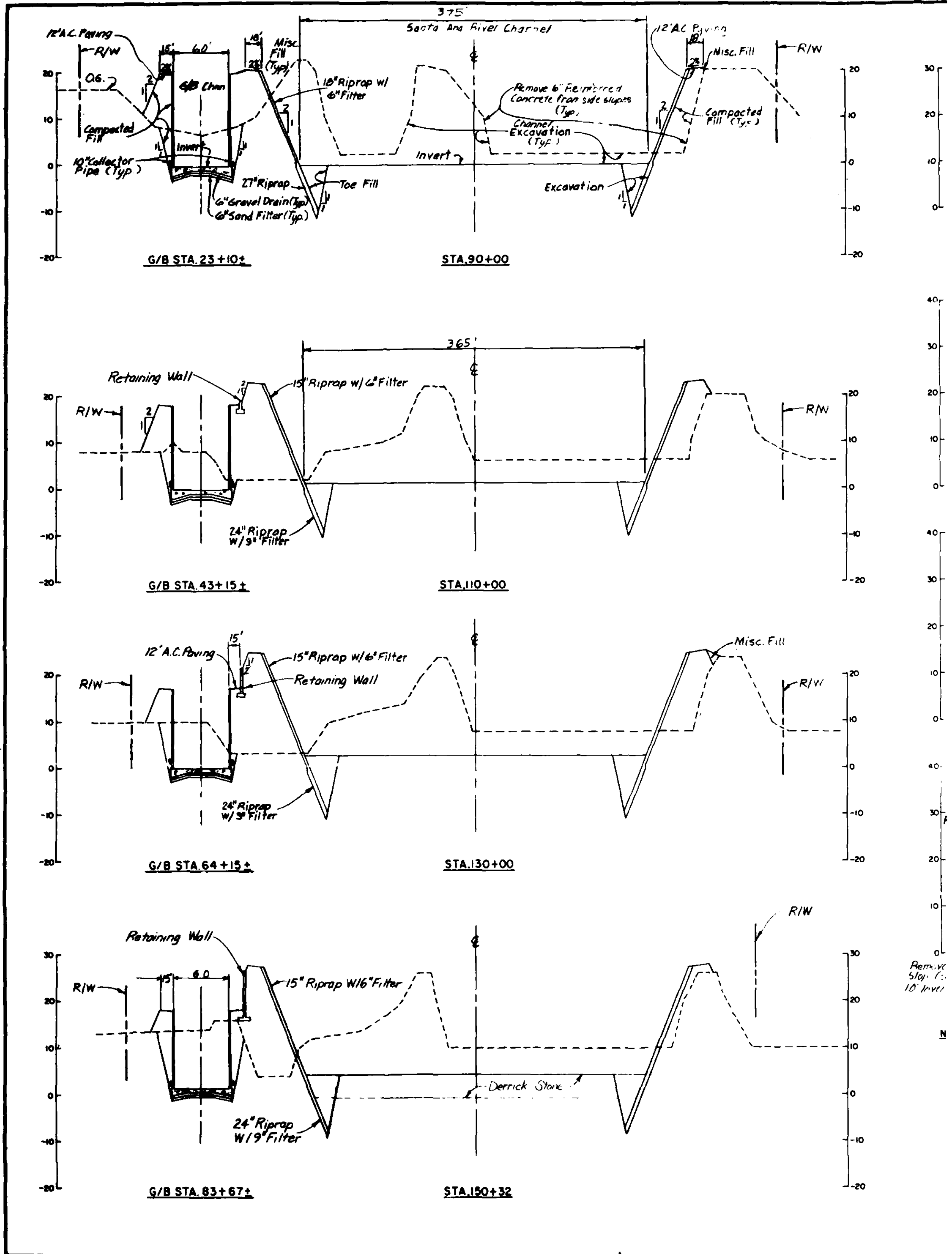
DISTRICT FILE NO.

SHEET 57 OF 108 SHEETS

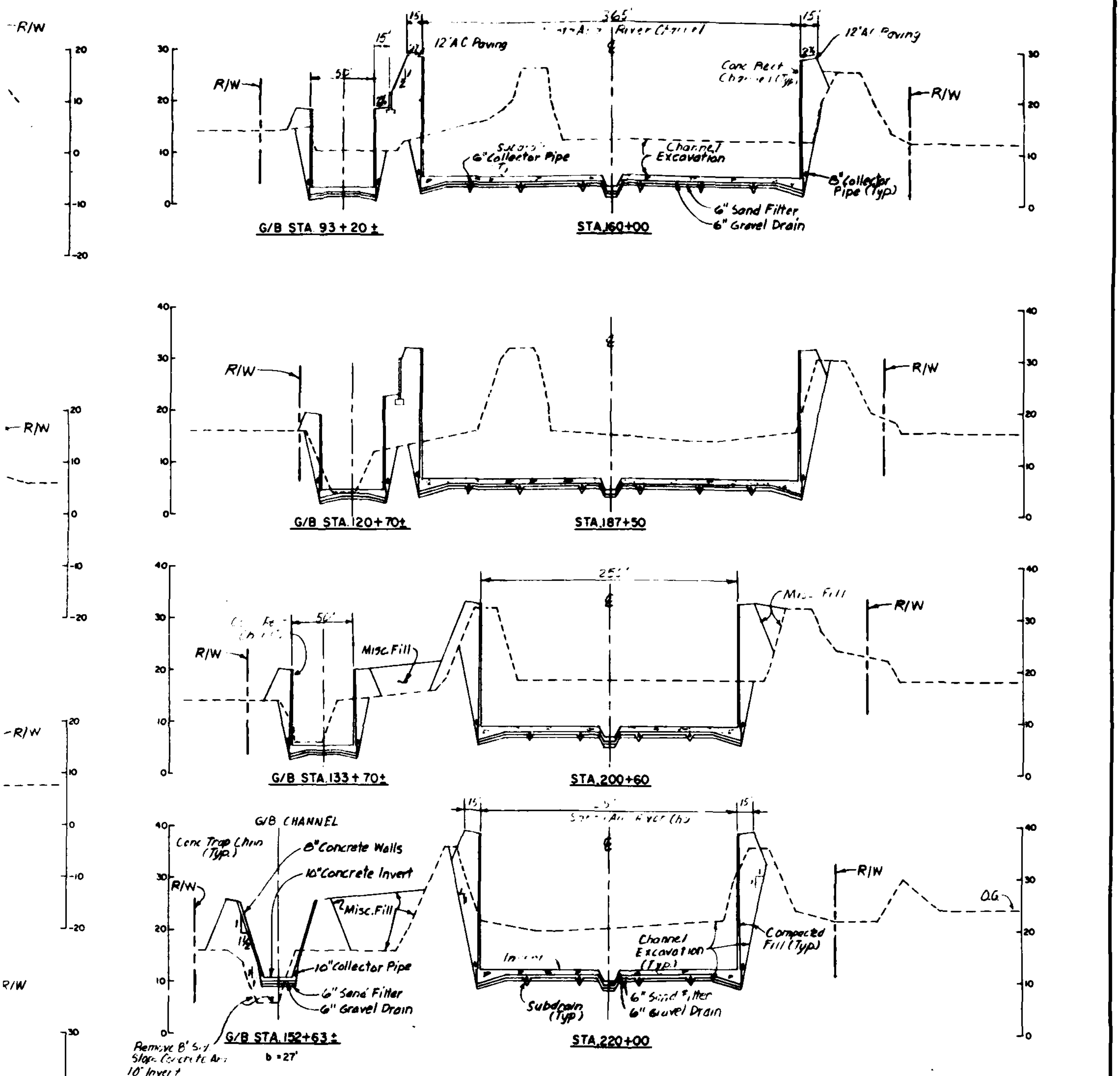
PLATE 80

1

2



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



NOTE:

1. FILTER MATERIAL FOR TRAPEZOIDAL CHANNEL SECTIONS IS CALLED OUT BUT NOT SHOWN.
2. SECTIONS ARE VIEWED LOOKING DOWNSTREAM.

VERT. SCALE 10 0 10 20 30 FEET — SCALE: 1 IN. = 10 FT.

HORIZ. SCALE 50 0 50 100 150 FEET — SCALE: 1 IN. = 50 FT.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY:

DRAWN BY: D.VILPPU

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL

CROSS SECTIONS

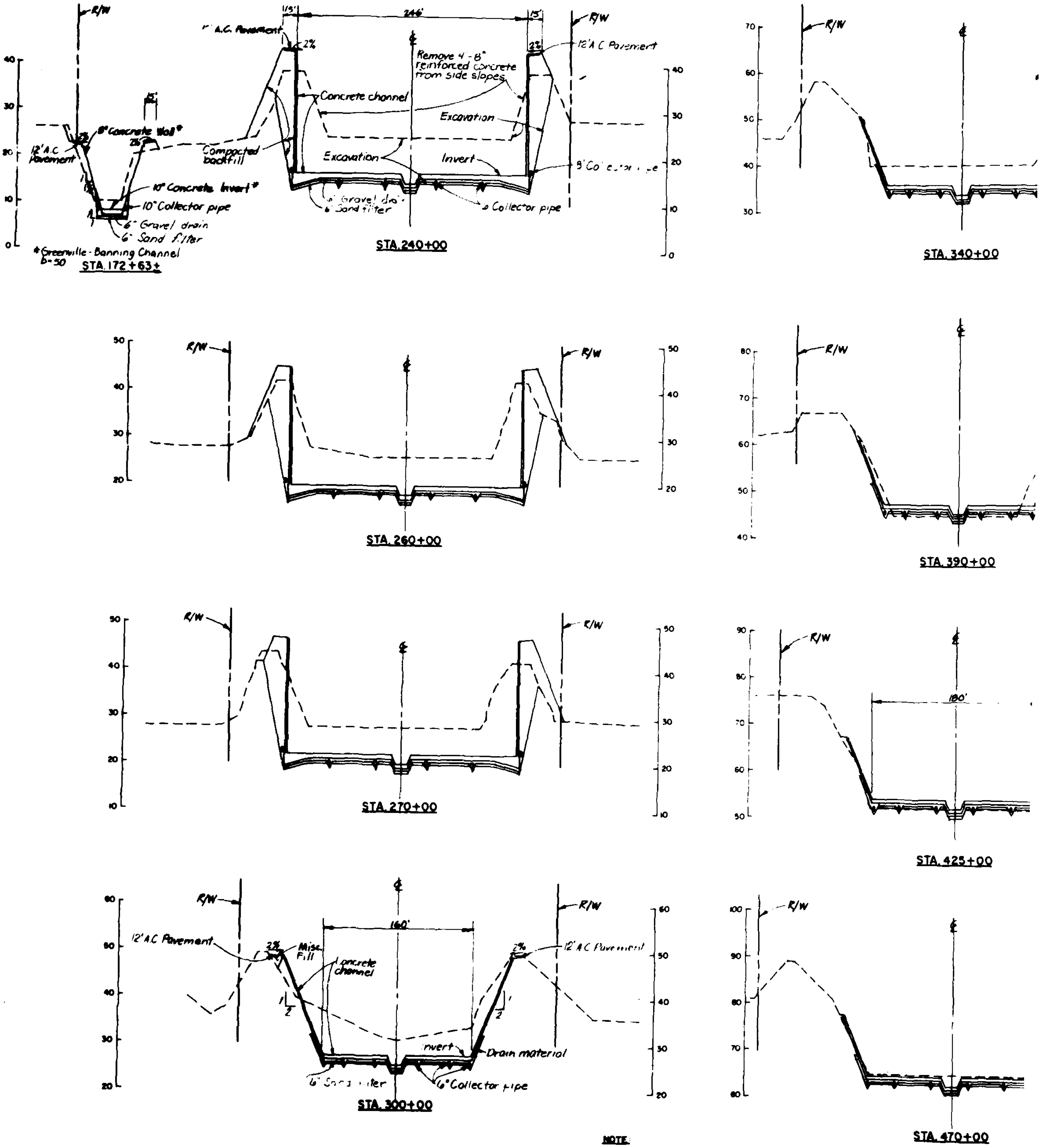
SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

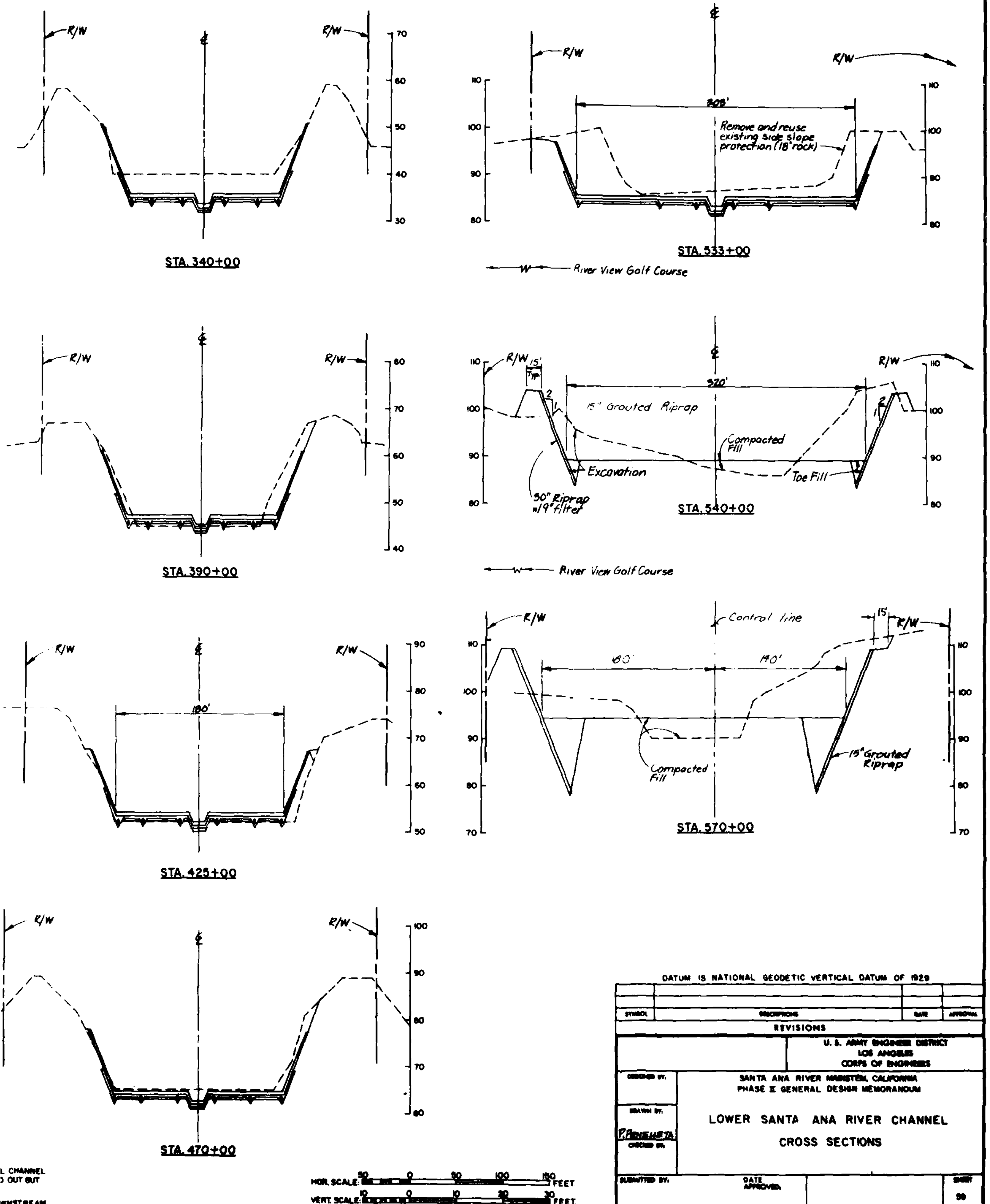
SHEET 58 OF 105 SHEETS

PLATE 61



NOTE:
1 FILTER MATERIAL FOR TRAPEZOIDAL CHANNEL SECTION AT STA 540+00 IS CALLED OUT BUT NOT SHOWN
2 SECTIONS ARE VIEWED LOOKING DOWNSTREAM

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

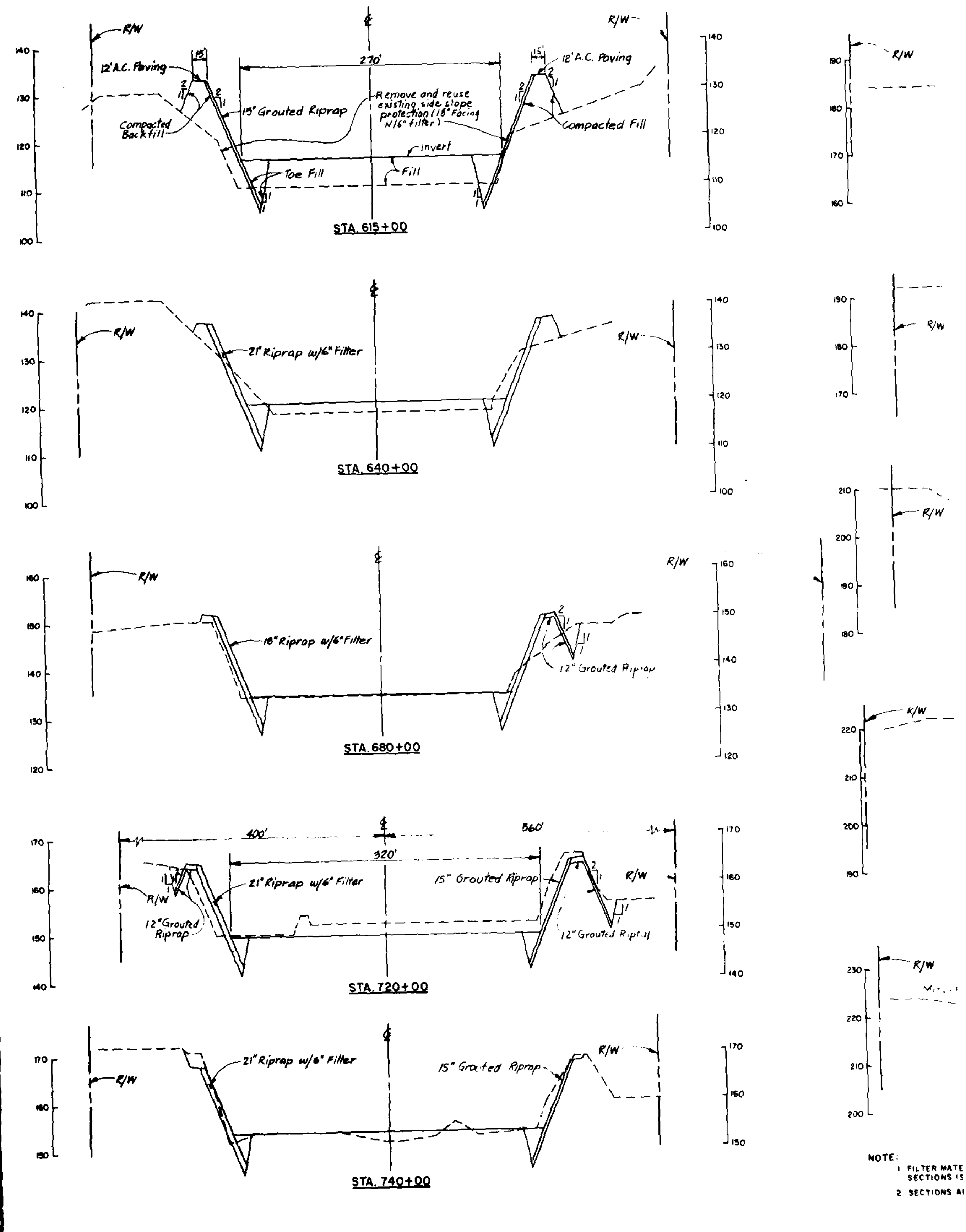
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
CROSS SECTIONS

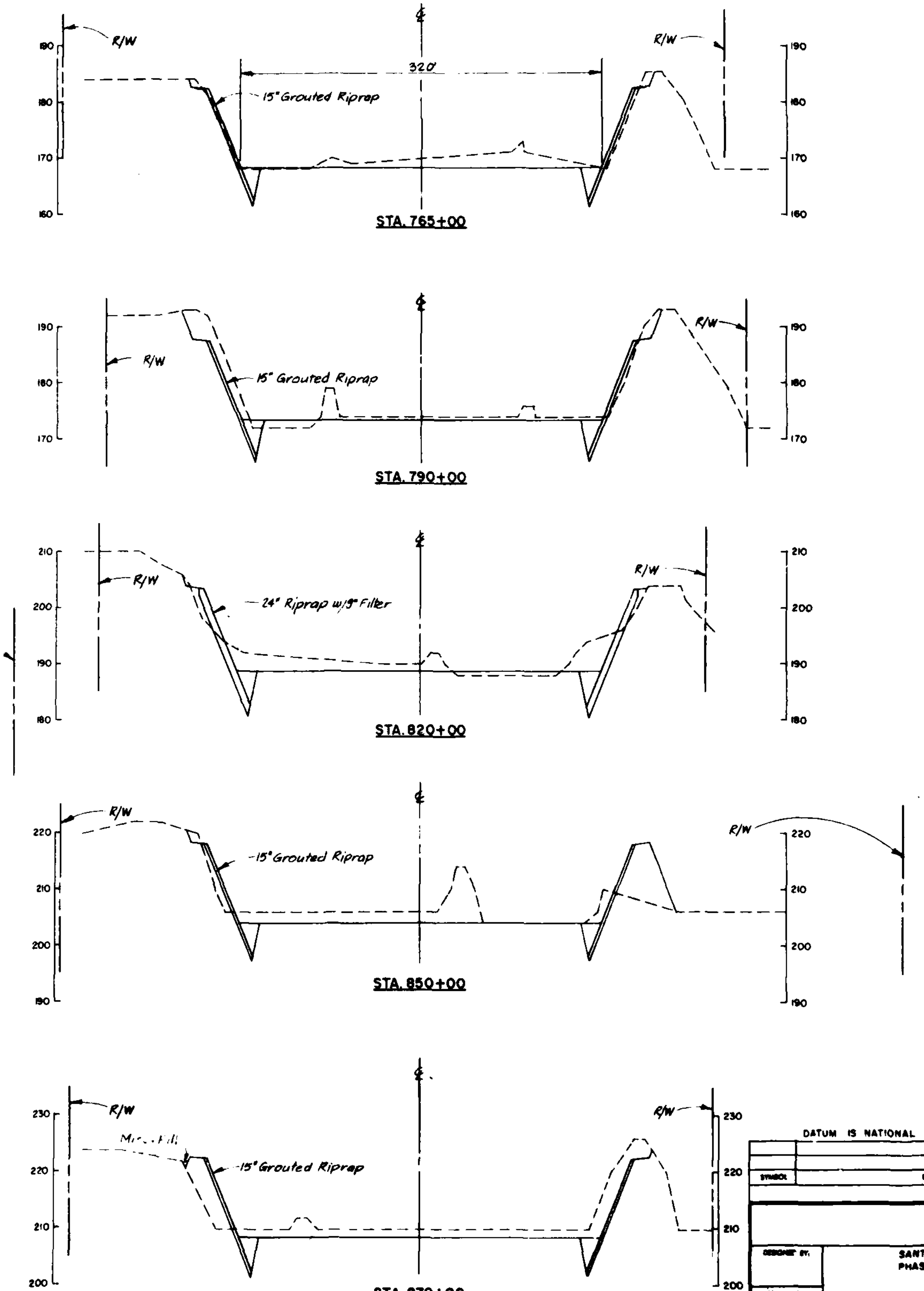
DESIGNED BY:
DRAWN BY: P. Penuela
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 59 OF 106 SHEETS

PLATE 62

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



LUE ENGINEERING PAYS



NOTE:
1 FILTER MATERIAL FOR TRAPEZOIDAL CHANNEL SECTIONS IS CALLED OUT BUT NOT SHOWN.
2 SECTIONS ARE VIEWED LOOKING DOWNSTREAM

HOR. SCALE: 30 0 50 100 150 FEET
VERT. SCALE: 10 0 10 20 30 FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
CROSS SECTIONS

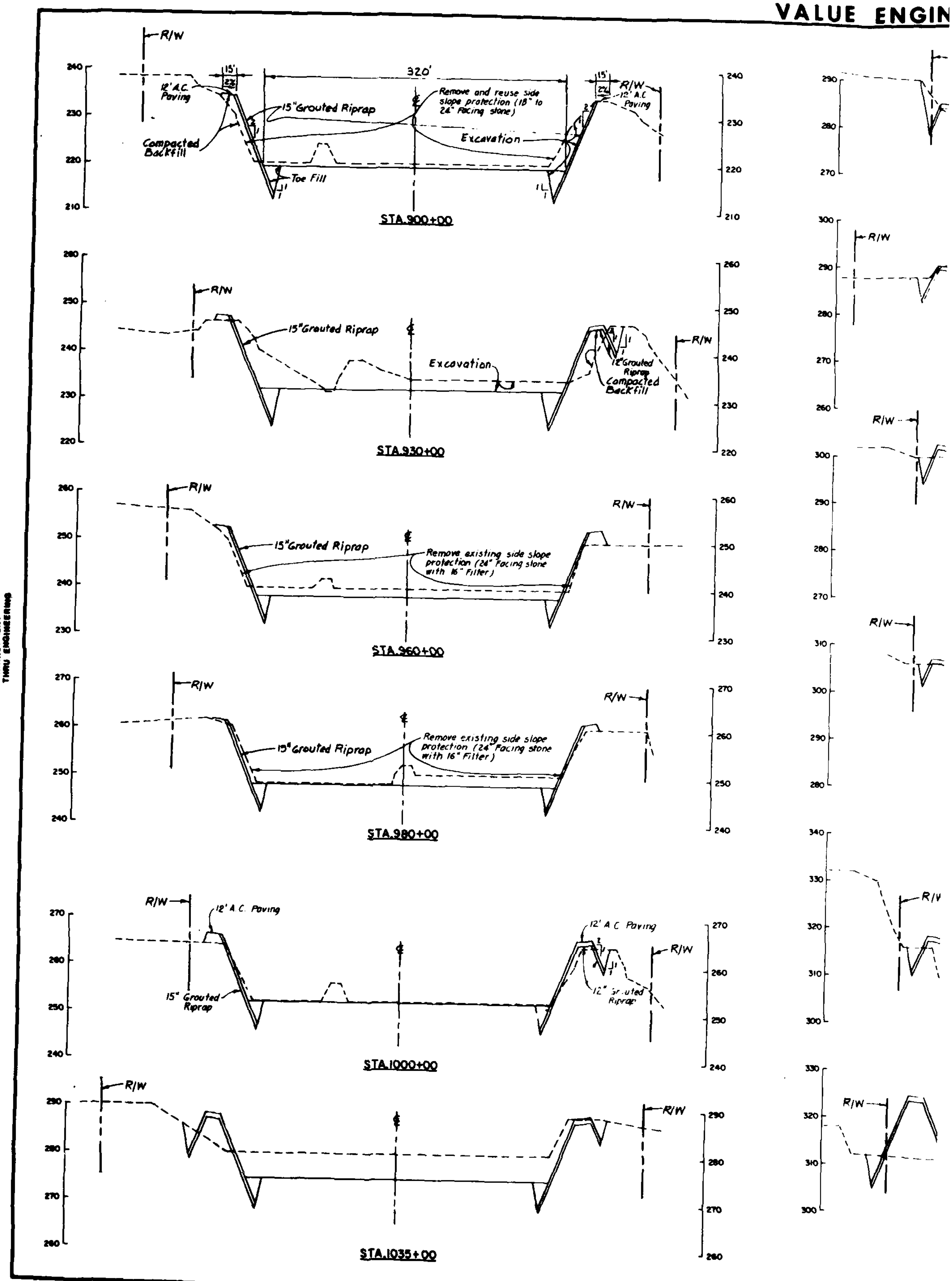
DESIGNED BY:
DRAWN BY: P. PENUELA
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 60 OF 105

SAFETY PAYS

PLATE 63

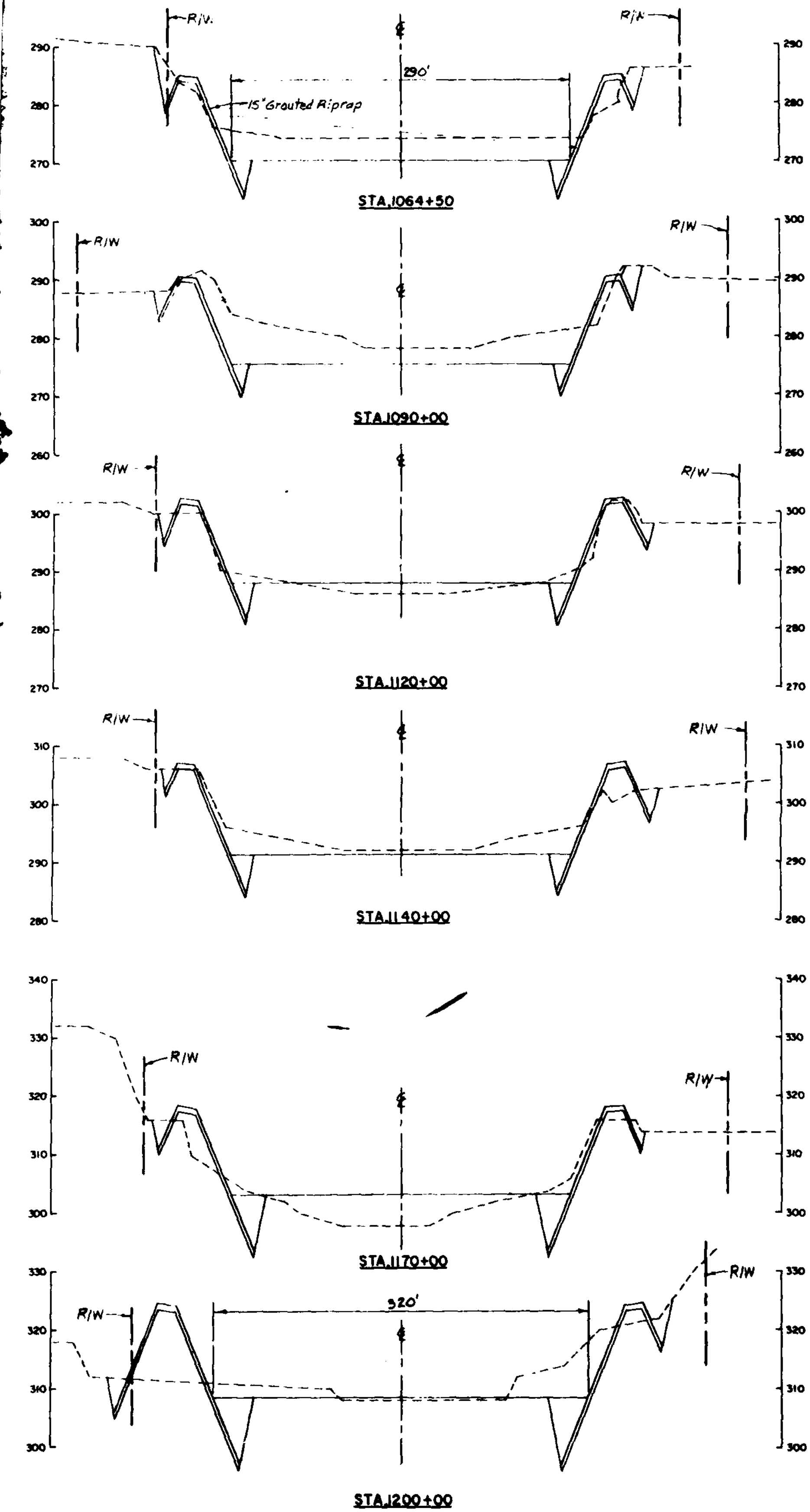
2

VALUE ENGIN



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY



NOTE:
SECTIONS ARE VIEWED LOOKING DOWNSTREAM.

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D.VILPPU

LOWER SANTA ANA RIVER CHANNEL
CROSS SECTIONS

SUBMITTED BY: | DATE APPROVED: | DISTRICT FILE NO. | SHEET 61 OF 105 SHEETS

PLATE 64

2

INDEX NO.	SHT. NO.	STATION		DESCRIPTION		AGENCY	PROPOSED WORK: TO BE RELOCATED	PROPOSED WORK: PROTECT IN PLACE
1	1-3	1535+60	1609+80	Sewer	48"-Dia. R.C.P.	UNKNOWN		●
2	2-3	1538+10	1544+00	Water	108"-Dia. Steel Pipe	Metropolitan Water District		●
3	3	1508+00	1535+60	Sewer	42"-Dia. Pipe	Southern California Edison Company		●
4	3	1483+85		Electrical	Aerial Line	Southern California Edison Company		●
5	3-4	1445+10	1480+70	Electrical	Aerial Line	County Sanitation Districts of Orange County		●
6	4	1435+00	1465+50	Sewer	39"-Dia. V.C.P.	UNKNOWN		●
7	4-5	1417+60	1435+00	Sewer	45"-Dia. R.C.P.	Municipal Water District of Orange County		●
8	5	1386+90	1417+60	Sewer	42"-Dia. V.C.P.	Municipal Water District of Orange County		●
9	5-7	1283+20	1366+90	Sewer	45"-Dia. R.C.P.	City of Anaheim		●
10	8	1207+60	1222+70	Electrical	Aerial Line	City of Anaheim		●
11	10	1208+33		Electrical	Aerial Line	UNKNOWN		●
12	10	1208+20		Water	73"-Dia. Steel Pipe w/encasement	Metropolitan Water District		●
13	10	1201+10		Electrical	220 KV Aerial Line	Southern California Edison Company		●
14	10	1198+25		Electrical	220 KV Aerial Line	Southern California Edison Company		●
15	10	1195+80	1208+70	Sewer	51"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
16	12	1124+20		Electrical	Aerial Line	UNKNOWN		●
18	14	1076+37		Water	109"-Dia. Steel Pipe w/encasement	Municipal Water District of Orange County		●
19	14	1086+25		Electrical	6.9 KV Aerial Line x 12	City of Anaheim		●
20	14	1085+93		Water	21"-Dia. Steel Pipe	City of Anaheim		●
21	14	1085+80		Gas	8"-Dia. Steel Pipe w/encasement	Southern California Gas Company		●
22	14	1084+73		Sewer	33"-Dia. V.C.P. w/encasement	County Sanitation Districts of Orange County		●
23	16	1028+83		Electrical	6.9 KV Aerial Line x 12	City of Anaheim		●
24	18	984+00		Electrical	6.9 KV Aerial Line x 12	City of Anaheim		●
25	16-18	973+55	1005+97	Water	12"-Dia. Pipe	City of Anaheim		●
26	18	953+42		Electrical	66 KV Aerial Line	City of Anaheim		●
27	19	938+44		Water	79"-Dia. Steel Pipe w/encasement	Metropolitan Water District		●
28	19	935+88		Water	14"-Dia. Steel Pipe	Peralta Hills Water Company	●	
29	19	922+74		Electrical	6.9 KV Aerial Line x 12	City of Anaheim		●
30	19	918+63		•	8"-Dia. Steel Pipe	UNKNOWN		●
31	19	918+25		Water	12"-Dia. Steel Pipe	City of Anaheim		●
32	20	902+20		Electrical	Aerial Line	Southern California Edison Company		●
33	18-20	901+70	958+22	Electrical	Aerial Line x 2	Southern California Edison Company		●
34	20	888+50		Electrical	Aerial Line	UNKNOWN		●
35	20	886+34		Gas	36"-Dia. H.P.	Southern California Gas Company		●
36	20	885+45	888+68	Sewer	18"-Dia. V.C.P. w/encasement	UNKNOWN		●
37	21	857+59		Telephone	3"-Dia. Conduit x 12	Pacific Telephone and Telegraph		●
38	21	857+49		Telephone	3"-Dia. Conduit x 14	Pacific Telephone and Telegraph		●
39	20-21	855+00	888+20	Sewer	78"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
40	23	821+25		Telephone	4"-Dia. Conduit x 24	Pacific Telephone and Telegraph		●
41	23	821+05		Electrical	6.9 KV Aerial Line x 12	City of Anaheim		●
42	23	820+58		Gas	22"-Dia. H.P. w/encasement	Southern California Gas Company	●	
43	24-25	758+90	804+90	Electrical	Aerial Line	UNKNOWN		●
44	25	754+00		Oil	16"-Dia. Crude Line	Four Corners Pipe Company		●
45	25	749+63		Telephone	3.5"-Dia. Conduit	Pacific Telephone and Telegraph		●
46	25	748+94		Water	8"-Dia. Steel Pipe	UNKNOWN		●
47	25	737+00		Electrical	Aerial Line x 8	Southern California Edison Company		●
48	25-26	735+80		Electrical	Aerial Line x 8	Southern California Edison Company		●
49	25-26	734+60		Electrical	Aerial Line x 8	Southern California Edison Company		●
50	26	733+15		•	8"-Dia. Conduit	UNKNOWN		●
51	21-26	710+70	855+00	Sewer	63"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
52	26	709+40		Electrical	Aerial Line	Southern California Edison Company	●	
53	26	709+20		Telephone	3.5"-Dia. Conduit x 6	Pacific Telephone and Telegraph	●	
54	26	708+60		Water	6"-Dia. D.I.P.	City of Orange Water Department	●	
55	26	708+20		Sewer	24"-Dia. V.C.P.	County Sanitation Districts of Orange County	●	
56	27	694+88		Electrical	Aerial Line	Southern California Edison Company		●
57	27	694+30		Electrical	Aerial Line	Southern California Edison Company		●
58	26-27	693+90	710+70	Sewer	66"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
59	27	693+30		Communication	T-Span Line	Western Union Telegraph Company		●
60	28	658+43		Water	10"-Dia. C.I.P.	City of Orange Water Department		●
61	29	638+15		Communication	2"-Dia. Steel Pipe	Cable Vision of Orange		●
62	29	638+00		Gas	12"-Dia. H.P. w/encasement	Southern California Gas Company		●
63	29	638+83		Telephone	4"-Dia. Conduit x 36	Pacific Telephone and Telegraph		●
64	29	638+71		Electrical	Underground Line	Southern California Edison Company		●
65	29	638+56		Telephone	4"-Dia. Conduit x 27	Pacific Telephone and Telegraph		●
66	29	632+40	635+75	Water	16"-Dia. D.I.P.	City of Orange Water Department		●
67	29	632+37		Water	16"-Dia. D.I.P.	City of Orange Water Department		●
68	29	623+83		Gas	8"-Dia. Steel Fuel Aerial	Getron Industries, Inc.		●
69	29	620+75	632+57	Gas	34"-Dia. Line	Southern California Gas Company		●
70	29	620+65	637+80	Water	16"-Dia. Pipe	City of Orange Water Department		●
71	30	609+00		Sewer	24"-Dia. Pipe w/encasement x 2	County Sanitation Districts of Orange County	●	
72	30	608+77		Sewer	30"-Dia. V.C.P.	County Sanitation Districts of Orange County	●	
73	30	608+50		Sewer	27"-Dia. V.C.P.	UNKNOWN	●	
74	29-30	607+90	638+30	Sewer	12"-Dia. V.C.P.	City of Orange		●
75	29-30	594+06	635+83	Water	16"-Dia. R.C.P.	City of Orange Water Department		●
76	30	591+85		Water	34"-Dia. Steel Pipe w/encasement	Metropolitan Water District		●
77	31	583+24		•	4"-Dia. Pipe	UNKNOWN	●	
78	31	583+12		•	5"-Dia. Conduit x 4	UNKNOWN	●	
79	31	583+00		Electrical	Aerial Line	Southern California Edison Company		●
80	31	582+71		Water	12"-Dia. Pipe	City of Santa Ana	●	
81	33	521+65		Gas	4"-Dia. Steel Pipe	Southern California Gas Company		●
82	33	520+95		Water	12"-Dia. Pipe	City of Santa Ana		●
83	33	520+73		•	8"-Dia. PVC x 3	UNKNOWN		●
84	27-33	510+40	693+90	Sewer	78"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
85	33	508+60		Water	12"-Dia. Pipe	City of Santa Ana	●	
86	33	508+30		Telephone	3.5"-Dia. Conduit x 18	Pacific Telephone and Telegraph	●	
87	34	473+77		Telephone	3.5"-Dia. Conduit x 18	Pacific Telephone and Telegraph		●
88	34	473+35		Water	12"-Dia. Pipe	City of Santa Ana		●
89	34	473+10		Electrical	Aerial Line	Southern California Edison Company		●
90	34	472+85	483+50	Sewer	10"-Dia. V.C.P.	City of Santa Ana Sanitation Department		●
91	35	458+38		Electrical	Aerial Line	Southern California Edison Company		●
92	35	458+70		Water	16"-Dia. Pipe	City of Santa Ana	●	
93	36	428+70		Water	12"-Dia. Pipe	County Sanitation Districts of Orange County		●
94	36	419+76		Electrical	Aerial Line	Southern California Edison Company		●
95	37	392+98		Gas	3"-Dia. Line w/encasement	Southern California Gas Company		●

INDEX NO
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ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

...LUE ENGINEERING PAYS

PROPOSED WORK	
...BE RELOCATED	PROTECT IN PLACE

INDEX NO.	SHT NO.	STATION		DESCRIPTION		AGENCY	PROPOSED WORK: TO BE RELOCATED	PROPOSED WORK: PROTECT IN PLACE
96	37	392+30		Electrical	Aerial Line	Southern California Edison Company		●
97	38	354+40		Electrical	Aerial Line	Southern California Edison Company		●
98	38	350+40		Telephone	Buried Cable	Pacific Telephone and Telegraph		●
99	38	349+65		Gas	10"-Dia. Line	Southern California Gas Company		●
100	38	348+82		Communication	T-Span Line	Western Union Telegraph Company		●
101	39	342+20		Gas	10"-Dia. Line	County Sanitation Districts of Orange County	●	
102	39	341+02		Telephone	4"-Dia. PVC Conduit x 2	Pacific Telephone and Telegraph		●
103	39	318+71		Telephone	4"-Dia. PVC Conduit x 4	Pacific Telephone and Telegraph		●
104	39	318+64		Telephone	4"-Dia. Conduit x 9	Pacific Telephone and Telegraph		●
105	39	318+32		Telephone	4"-Dia. Conduit x 9	Pacific Telephone and Telegraph		●
106	41	262+85		Water	2.5"-Dia. Pipe	Caltrans		●
107	41	257+30		Sewer	48"-Dia. R.C.P.	City of Santa Ana	●	
108	40-41	257+10	510+40	Sewer	84"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
109	41-42	257+09	305+29	Sewer	51"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
110	33-41	254+25	264+49	Sewer	84"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
111	42	252+24		Sewer	39"-Dia. V.C.P.	City of Santa Ana	●	
112	40-43	223+30	291+75	Electrical	220 KV Aerial Line x 2	Southern California Edison Company		●
113	42-43	212+35	229+00	Electrical	Aerial Line	Southern California Edison Company		●
114	43-44	172+00	220+80	Electrical	Aerial Line x 2	Southern California Edison Company		●
115	44	173+20		Electrical	Aerial Line	Southern California Edison Company		●
116	44	172+40		Water	24"-Dia. Pipe w/encasement	Mesa Consolidated Water District		●
117	45	159+26		Water	6"-Dia. A.C.P.	County Sanitation Districts of Orange County	●	
118	45	157+90		Water	16"-Dia. Steel Pipe	Mesa Consolidated Water District		●
119	46	117+58		Gas	30"-Dia. Line	Southern California Gas Company		●
120	46	116+93		Electrical	Aerial Line	Southern California Edison Company	●	
121	42-47	91+20	245+50	Water	30"-Dia. Steel Pipe	Mesa Consolidated Water District	●	
122	47	90+90		Electrical	Aerial Line	Southern California Edison Company	●	
123	47	90+07		Telephone	3.5"-Dia. Conduit x 6	Pacific Telephone and Telegraph	●	
124	47	89+85		Electrical	Aerial Line	Southern California Edison Company	●	
125	48	60+57		Electrical	Aerial Line	Southern California Edison Company		●
126	48	54+88		Water	12"-Dia. C.I.P. w/encasement	City of Newport Beach	●	
127	48	50+31		Oil	6"-Dia. Oil Line	County Sanitation Districts of Orange County	●	
128	48	48+49		Gas	6"-Dia. Line	County Sanitation Districts of Orange County	●	
129	48	48+15		Oil	6"-Dia. Crude Line	Standard Oil Company of California	●	
130	42-49	41+30	240+74	Gas	4"-Dia. Pipe	County Sanitation Districts of Orange County		●
131	42-49	41+30	239+00	Gas	6"-Dia. Line	County Sanitation Districts of Orange County		●
132	42-49	38+75	240+74	Sewer	Communication Cable	County Sanitation Districts of Orange County		●
133	42-49	36+74	238+95	Sewer	84"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
134	42-49	36+72	239+60	Sewer	66"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
135	43-49	33+75	223+00	Sewer	48"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
136	49	33+00		Sewer	42"-Dia. V.C.P.	County Sanitation Districts of Orange County	●	
137	49	32+78		Sewer	33"-Dia. R.C.P.	County Sanitation Districts of Orange County	●	
138	49	31+40		Sewer	24"-Dia. R.C.P.	County Sanitation Districts of Orange County	●	
139	49	31+20		Sewer	36"-Dia. R.C.P.	County Sanitation Districts of Orange County	●	
140	50	17+89		Electrical	Aerial Line	Southern California Edison Company	●	
141	50	17+39		Gas	12"-Dia. H.P.	Southern California Gas Company		●
142	50	17+34		*	8"-Dia. Steel Pipe	UNKNOWN		●
143	50	17+01		Telephone	3"-Dia. Iron Pipe	Pacific Telephone and Telegraph		●
144	50	16+94		Water	4"-Dia. Iron Pipe	UNKNOWN		●
145	49-50	15+87	26+50	Water	4"-Dia. Iron Pipe	City of Newport Beach		●
146	49-50	15+53	28+90	Sewer	14"-Dia. C.I.P.	City of Newport Beach		●
147	50	15+10		Sewer	14"-Dia. C.I.P.	City of Newport Beach		●
148	49-50	10+90	31+50	Sewer	42"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
149	49-50	10+22	33+42	Sewer	78"-Dia. R.C.P.	County Sanitation Districts of Orange County		●
150	49-50	10+22	33+35	Sewer	120"-Dia. R.C.P.	County Sanitation Districts of Orange County		●

* USE UNKNOWN

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL

UTILITY TABULATION

SUBMITTED BY: DATE APPROVED: DISTRICT FILE NO.

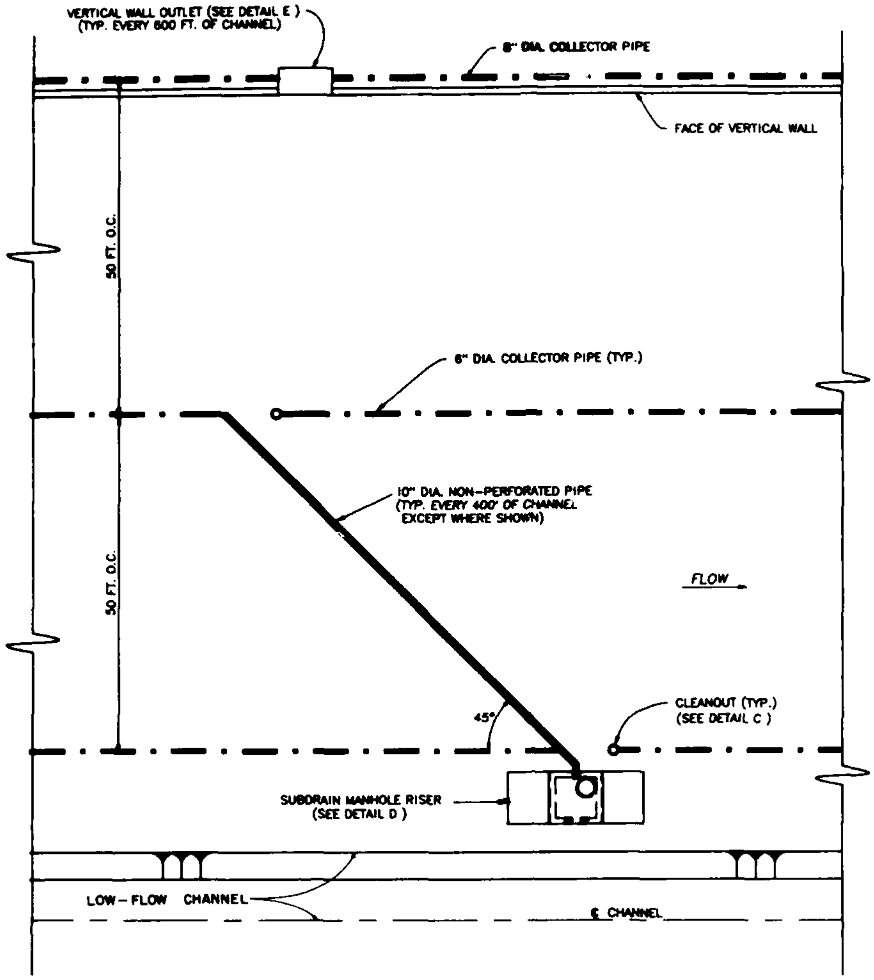
SHEET 92 OF 105 SHEETS

PLATE 65

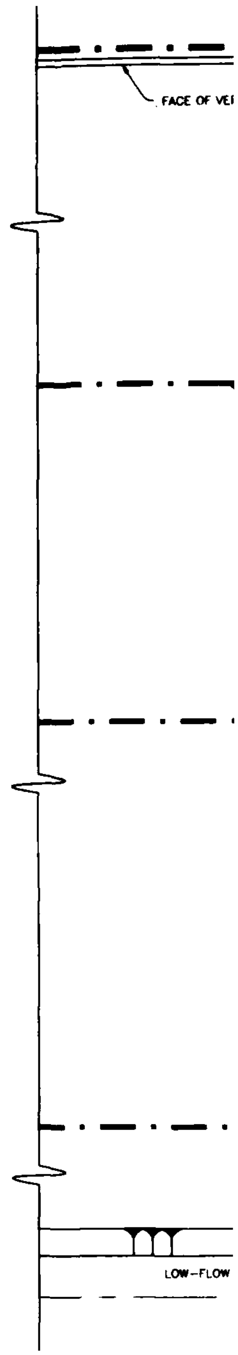
SAFETY PAYS

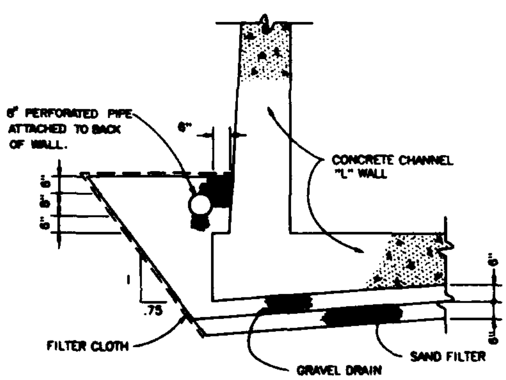
2

ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING

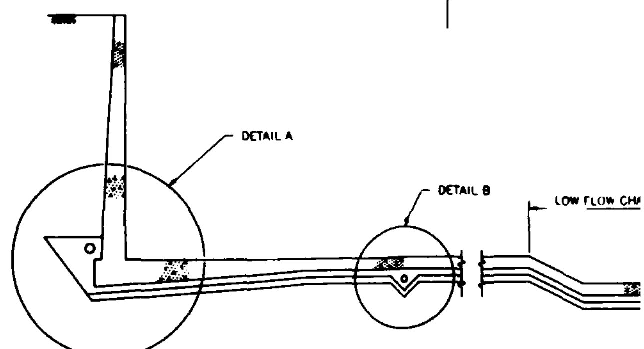


PLAN - RECTANGULAR CHANNEL
STA 191+85 TO STA 273+00
1 IN. = 1 FT.

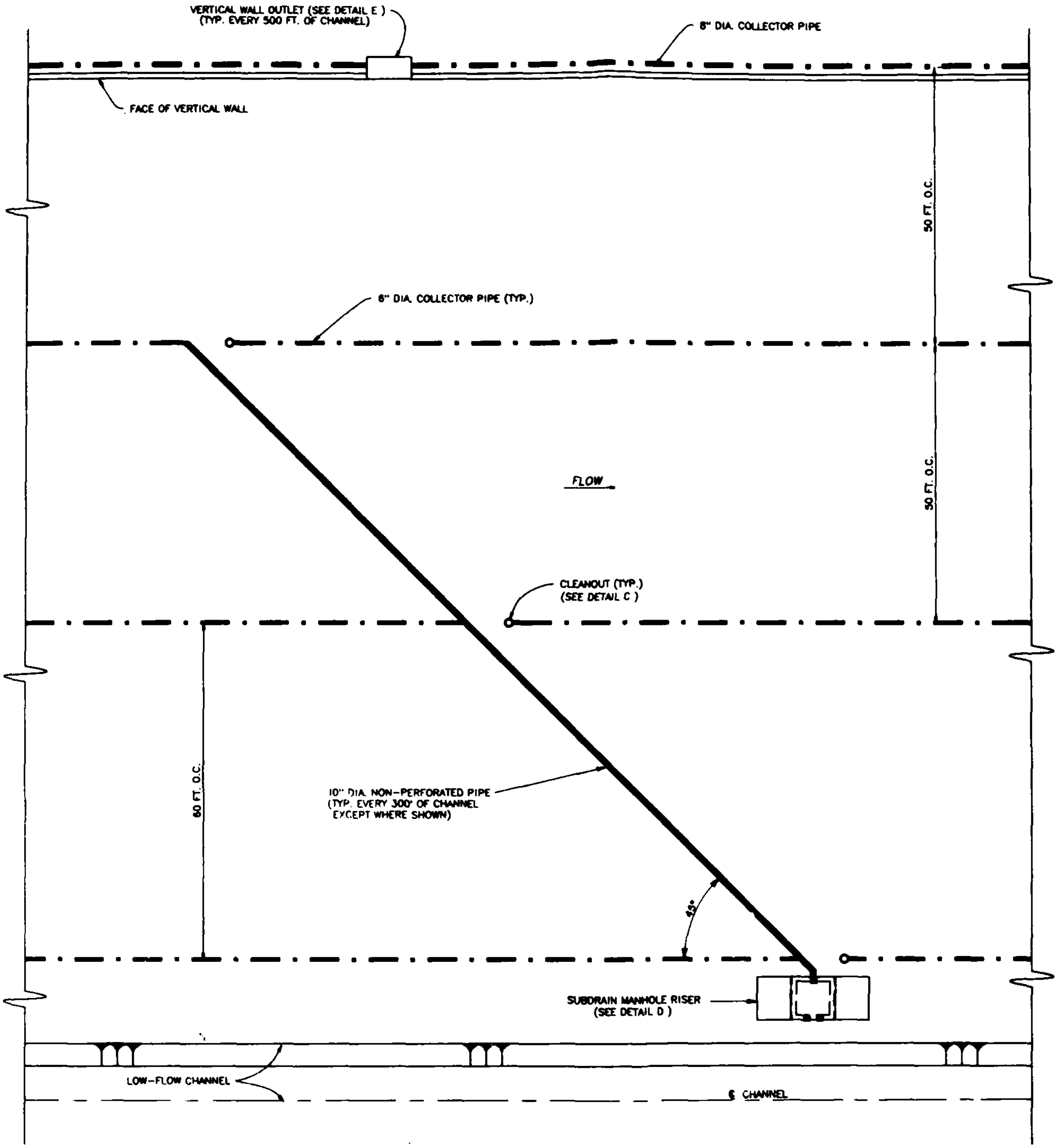




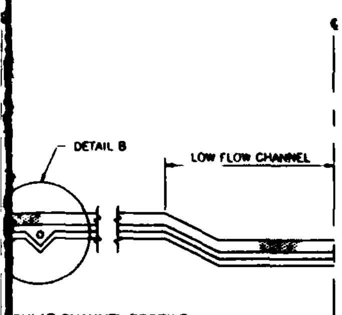
DETAIL - A
NOT TO SCALE



RECTANGULAR CHANNEL PROFILE
NOT TO SCALE



PLAN - RECTANGULAR CHANNEL
STA 150+32 TO STA 191+85
1 IN.= 1 FT.



...ULAR CHANNEL PROFILE
NOT TO SCALE

NOTE:
SEE SHEET 64 FOR DETAILS C,D, AND E.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

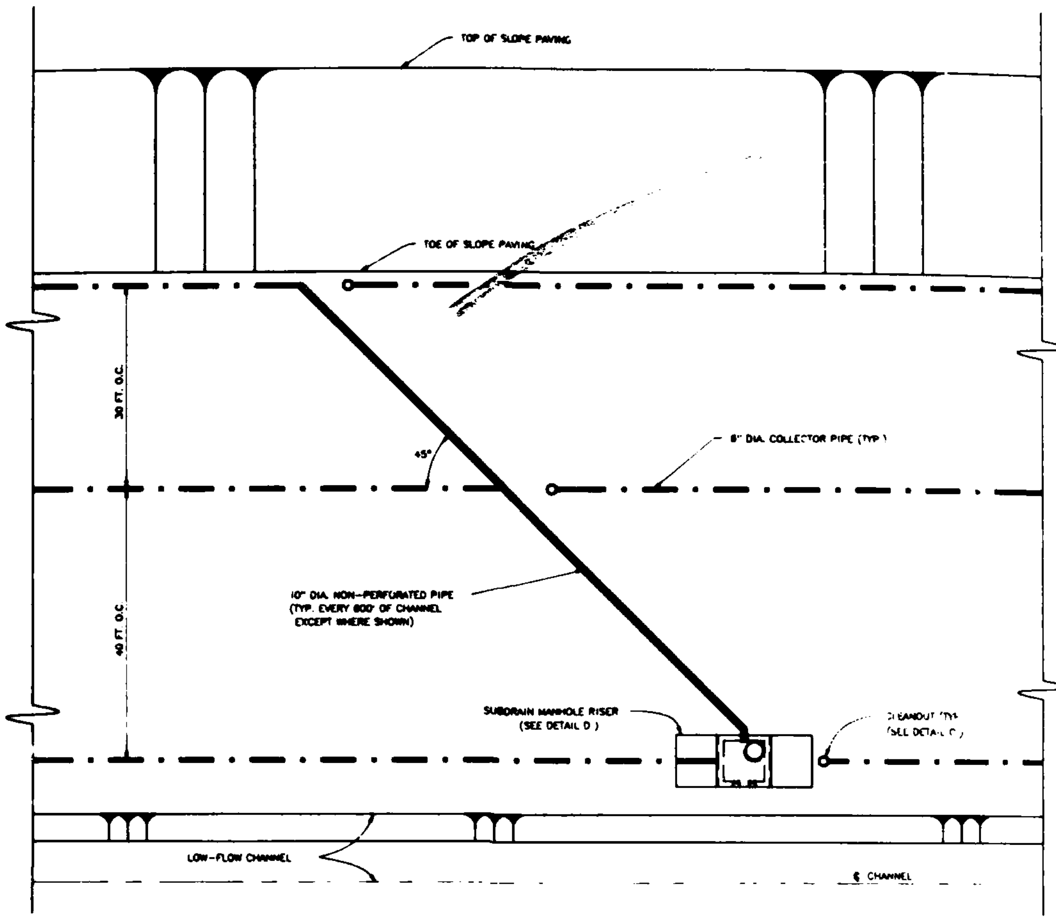
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
RECTANGULAR CHANNEL SUBDRAINAGE SYSTEM
STA. 150 + 32 TO STA 273+00

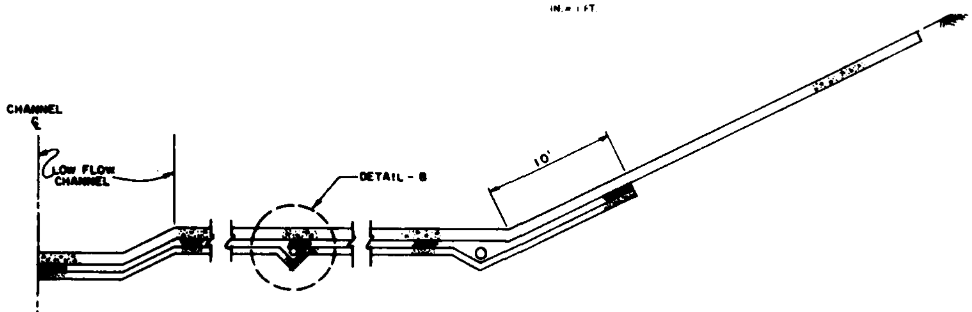
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 63 OF 105 SHEETS

PLATE 65

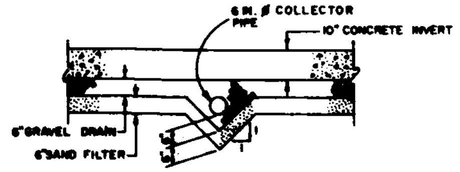
2



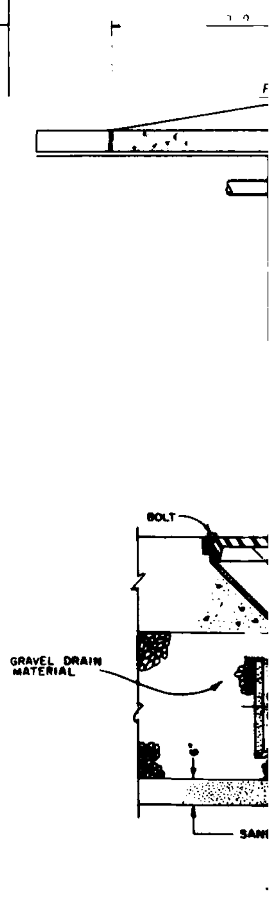
PLAN - TRAPEZOIDAL CHANNEL
STA 273+00 TO STA 535+80



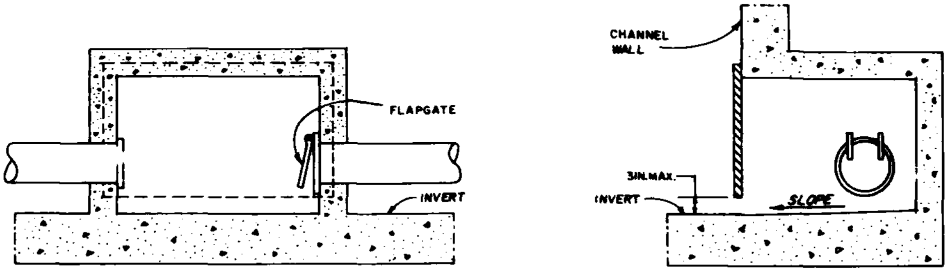
PROFILE - TRAPEZOIDAL CHANNEL
NOT TO SCALE



DETAIL - B
NOT TO SCALE

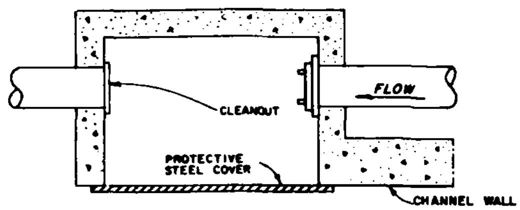


ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING



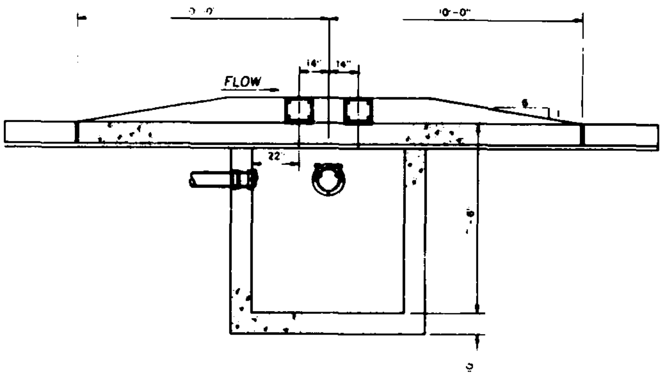
PROFILES
NOT TO SCALE

NOTE:
SEE PLATE FOR CHANNEL PLAN

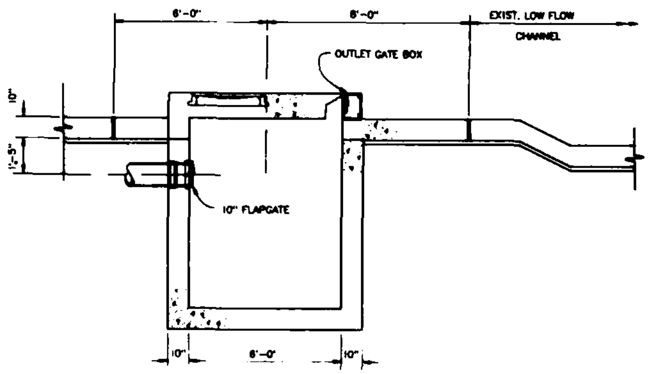


PLAN

DETAIL-E
VERTICAL WALL OUTLET
NOT TO SCALE

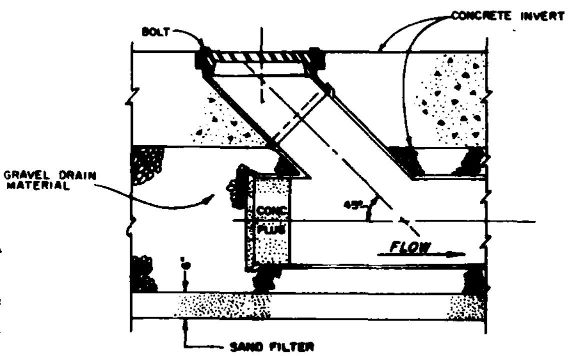


FRONT



SIDE

DETAIL-D
NOT TO SCALE



DETAIL-C
CLEANOUT
NOT TO SCALE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
TRAPAZOIDAL CHANNEL SUBDRAINAGE SYSTEM
STA. 273+00 TO STA. 535+80

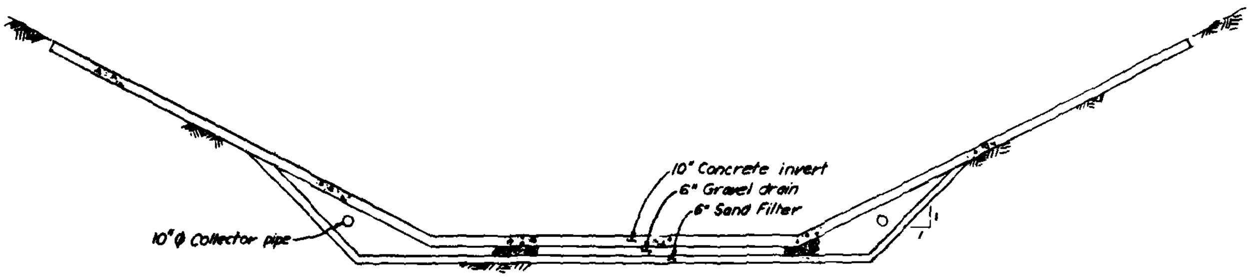
SUBMITTED BY: DATE APPROVED: DISTRICT FILE NO.

SHEET 64 OF 105 SHEETS

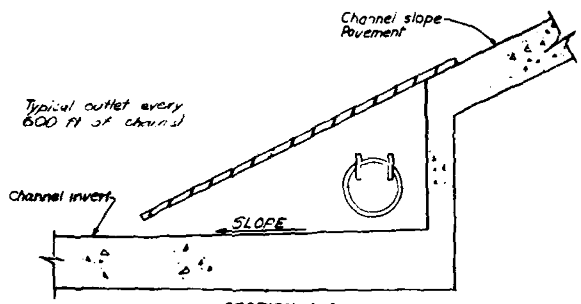
PLATE 67

2

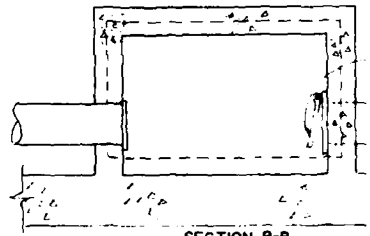
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



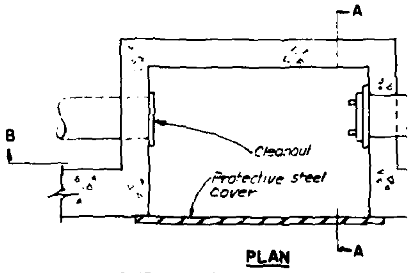
CROSS SECTION TRAPEZOIDAL CHANNEL
STA 177+00 TO STA 147+00
NOT TO SCALE



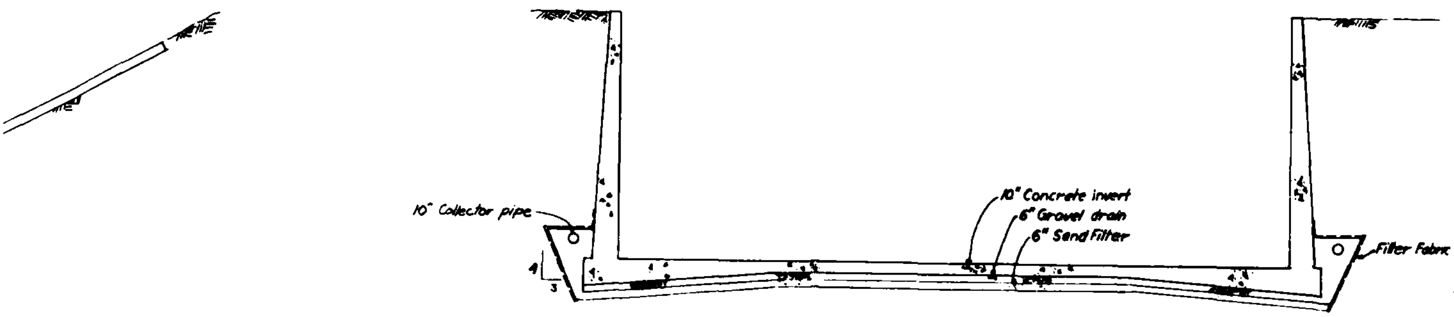
SECTION A-A
OUTLET CROSS SECTION
TRAPEZOIDAL CHANNEL
NOT TO SCALE



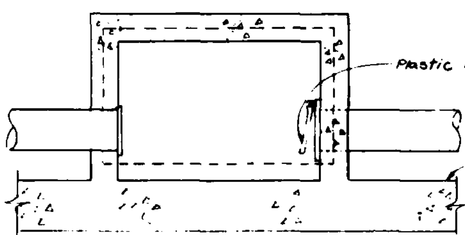
SECTION B-B
TYPICAL PROFILE
NOT TO SCALE



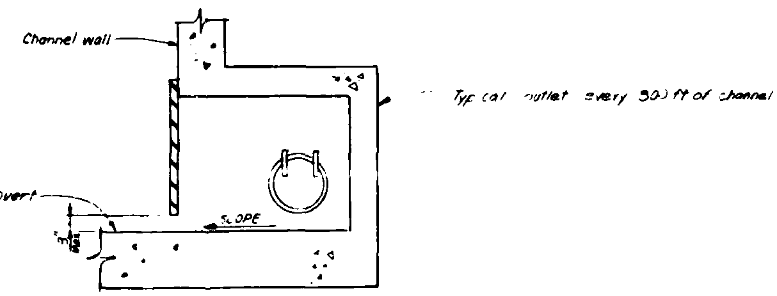
PLAN
TYPICAL SIDE OUTLET DETAIL
NOT TO SCALE



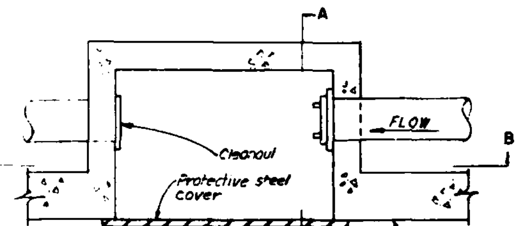
CROSS SECTION RECTANGULAR CHANNEL
STA 145+00 TO STA 9+50
NOT TO SCALE



SECTION B-B
TYPICAL
PROFILE
NOT TO SCALE



SECTION A-A
OUTLET CROSS SECTION
RECTANGULAR CHANNEL
NOT TO SCALE



PLAN
TYPICAL SIDE OUTLET DETAIL
NOT TO SCALE

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

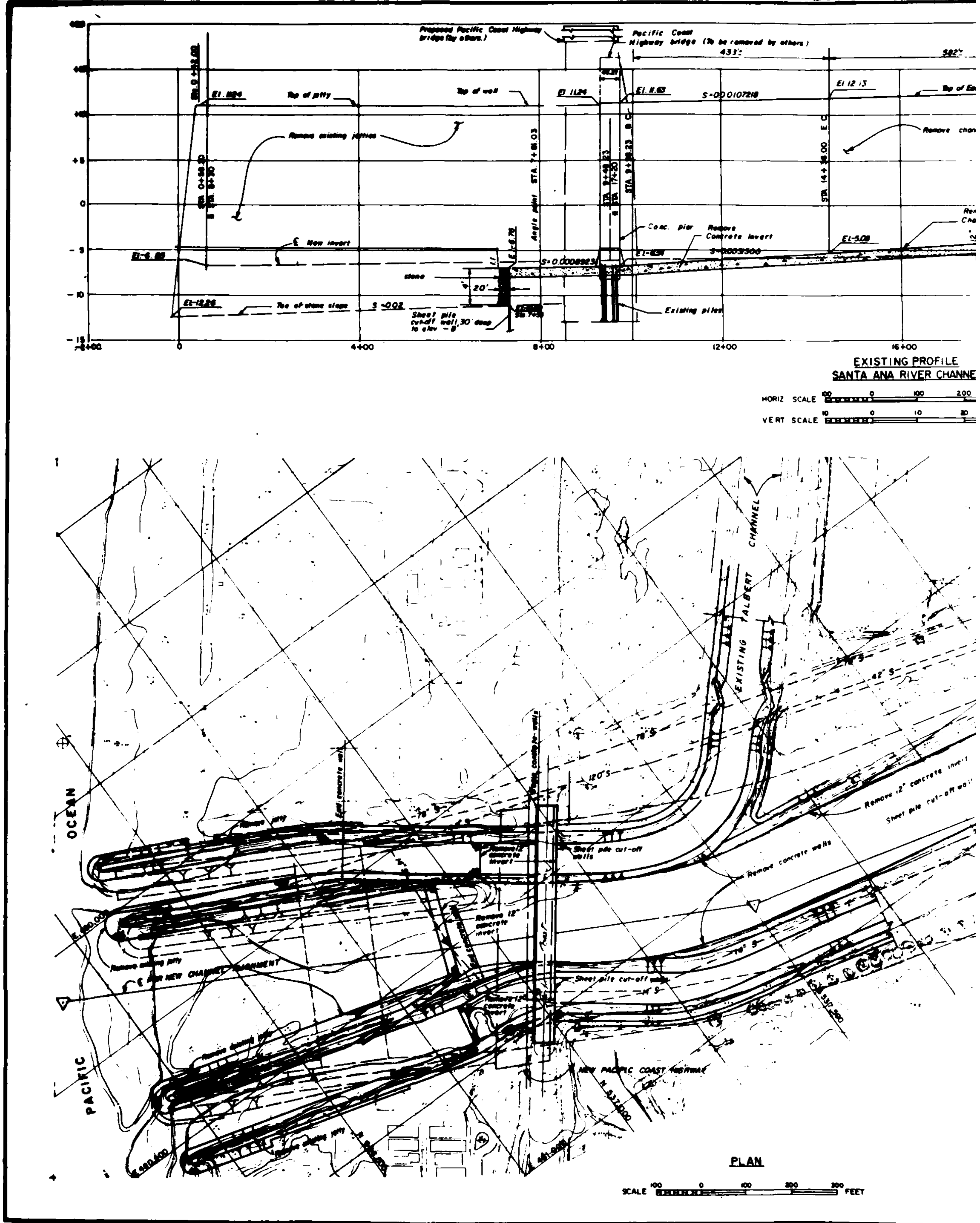
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

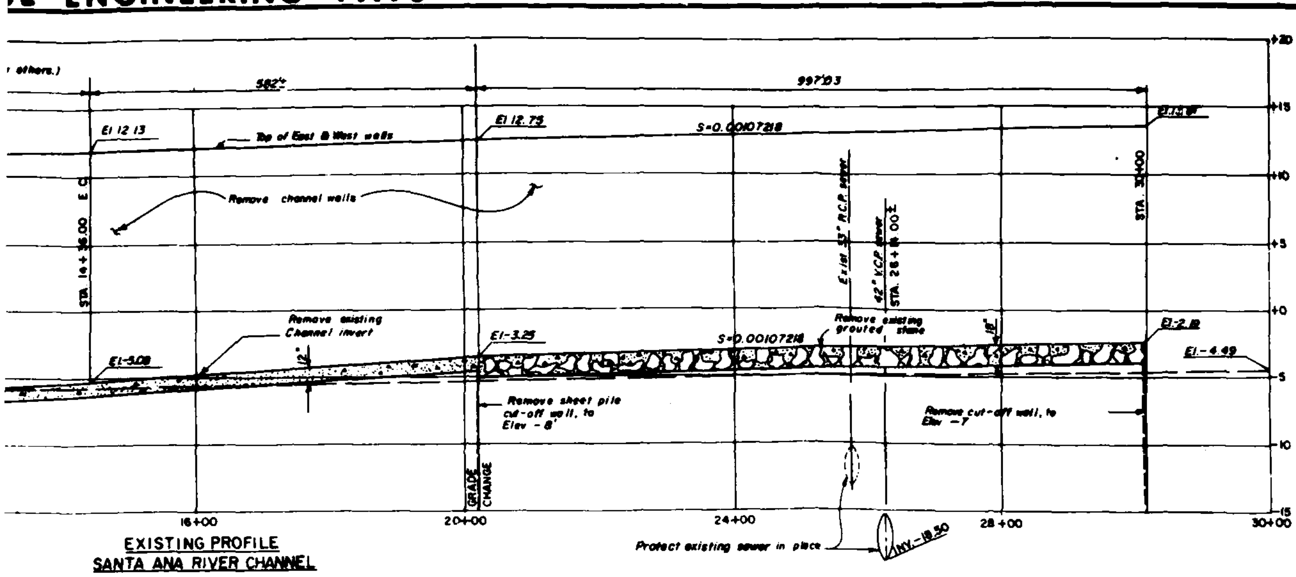
LOWER SANTA ANA RIVER CHANNEL
SUBDRAINAGE SYSTEM FOR
GREENVILLE - BANNING CHANNEL

SUBMITTED BY:
DISTRICT FILE NO.
SHEET 69 OF 105 SHEETS

PLATE 69

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



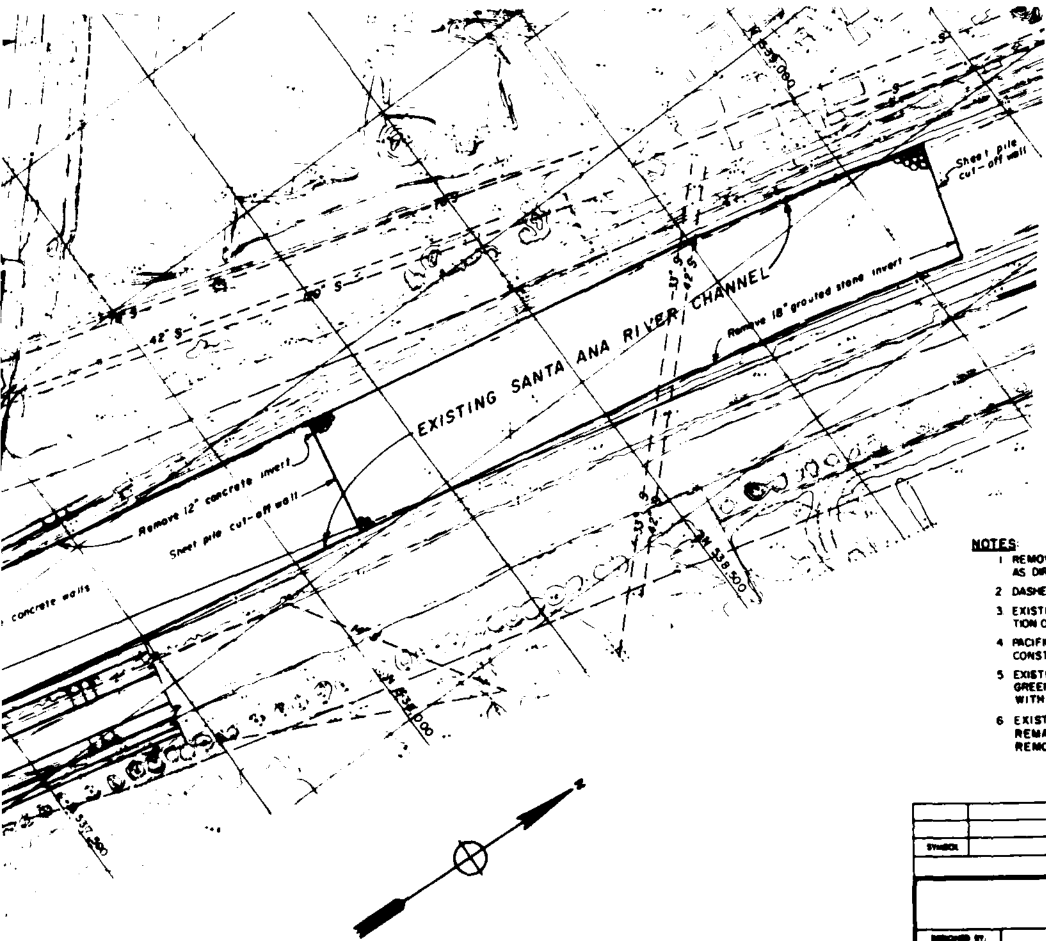


EXISTING PROFILE
SANTA ANA RIVER CHANNEL

HORIZ SCALE 100 0 100 200 300 FEET

VERT SCALE 10 0 10 20 30 FEET

■ DENOTES NEW CHANNEL STATIONS



200 300 FEET

NOTES:
1. REMOVE EXISTING STONE SIDESLOPES AND STOCKPILE FOR REUSE AS DIRECTED BY ENGINEER
2. DASHED LINES INDICATE PROPOSED CONSTRUCTION
3. EXISTING TALBERT CHANNEL TO BE RELOCATED PRIOR TO CONSTRUCTION OF CHANNEL MOUTH BY OTHERS
4. PACIFIC COAST HIGHWAY WIDENING AND BRIDGE ACROSS SAR TO BE CONSTRUCTED 1988-1989 BY OTHERS
5. EXISTING PROFILE FOR SAR CHANNEL SHOWN AS BUILTS OF GREENVILLE-BANNING AND TALBERT CHANNELS ON FILE WITH ENGINEER
6. EXISTING SAND PLUG DOWNSTREAM OF RECOMMENDED STABILIZE TO REMAIN, EXCEPT FOR THAT REQUIRED IN AREAS OF JETTY REMOVAL AND CONSTRUCTION.

SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: F. Castellanos
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
REMOVAL AT MOUTH

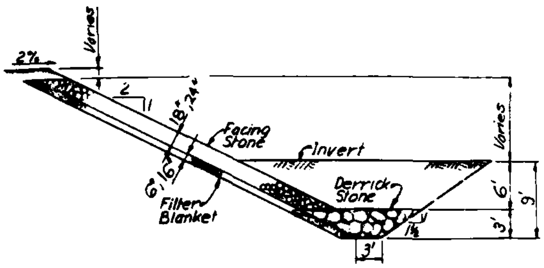
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 66 OF 105 SHEETS

PLATE 60

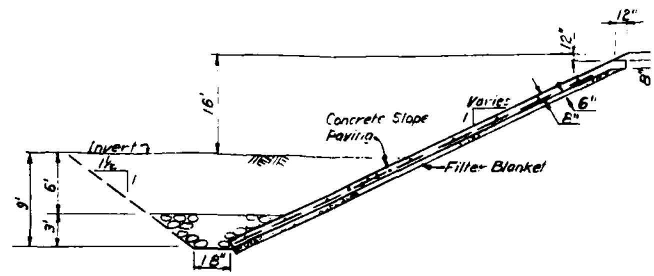
1

2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



WEIR CANYON ROAD TO KATELLA AVENUE
NOT TO SCALE

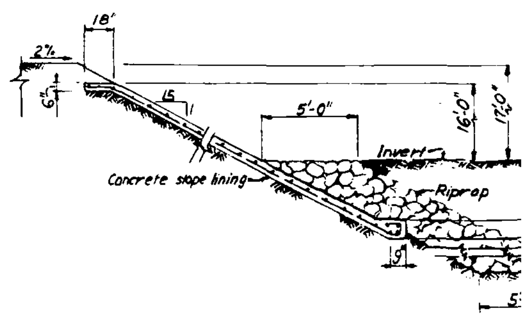


KATELLA AVENUE TO GARDEN GROVE FREEWAY
STA 710 TO STA 705
NOT TO SCALE

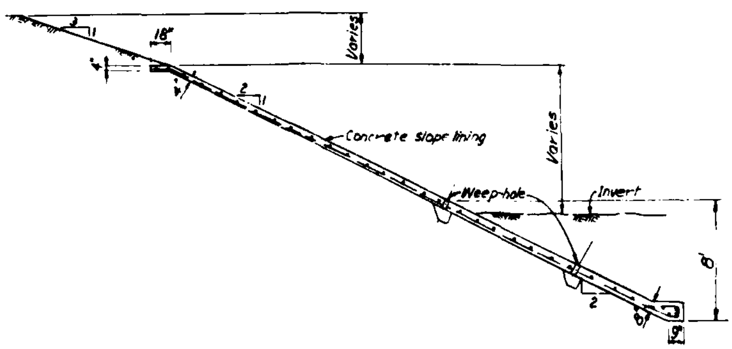
LIMITED EXISTING IMPROVEMENT

- PIPE AND WIRE FENCING.
- TURF STABILIZED EMBANKMENTS.

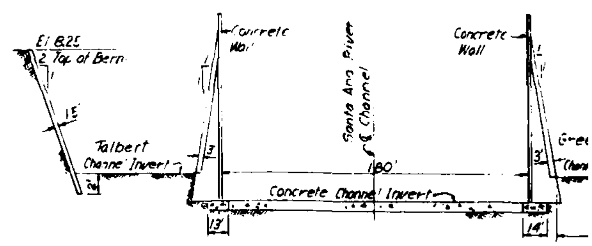
GARDEN GROVE FREEWAY TO 17TH STREET



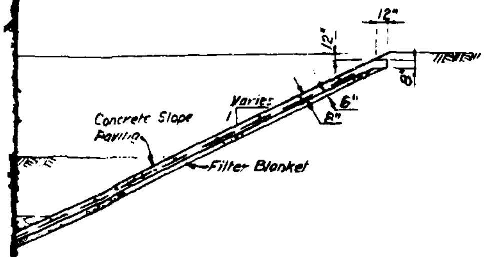
STA. 171 TO STA 28
NOT TO SCALE



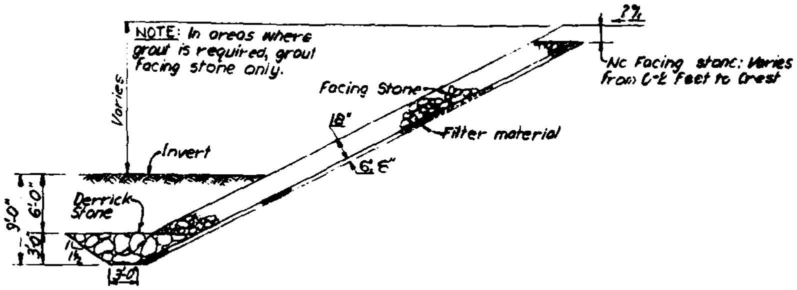
17TH STREET TO ADAMS AVENUE
NOT TO SCALE



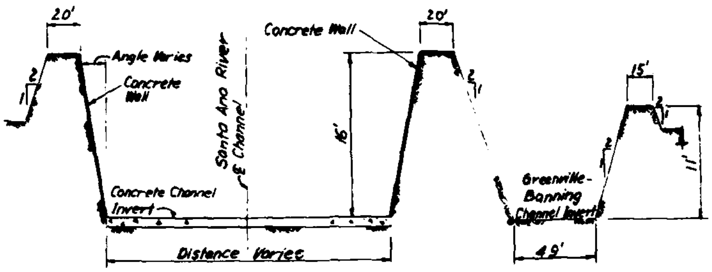
STA. 22 TO STA 15
NOT TO SCALE



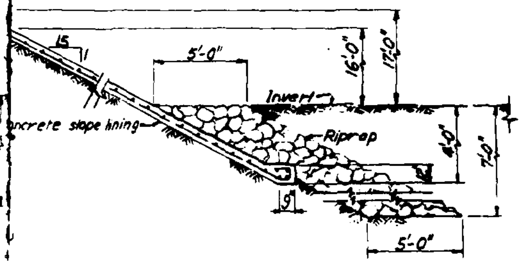
ENUE TO GARDEN GROVE FREEWAY
STA 710 TO STA 706
NOT TO SCALE



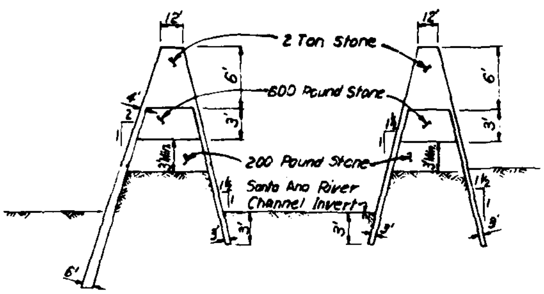
KATELLA AVENUE TO GARDEN GROVE FREEWAY
NOT TO SCALE



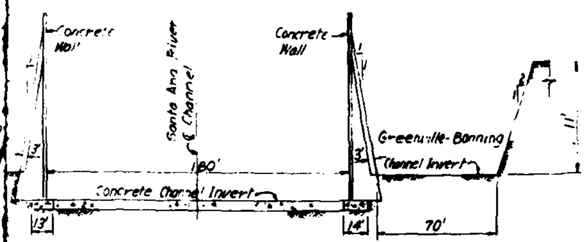
STA. 28 TO STA.22
NOT TO SCALE



STA 171 TO STA 28
NOT TO SCALE



STA 15 TO END
NOT TO SCALE



STA 22 TO STA 15
NOT TO SCALE

ADAMS AVE TO PACIFIC OCEAN

NOTES
1 SEE TABLE I FOR SPECIFIC EXISTING CONDITION INFORMATION.
2 SECTIONS ARE VIEWED LOOKING UPSTREAM.

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL

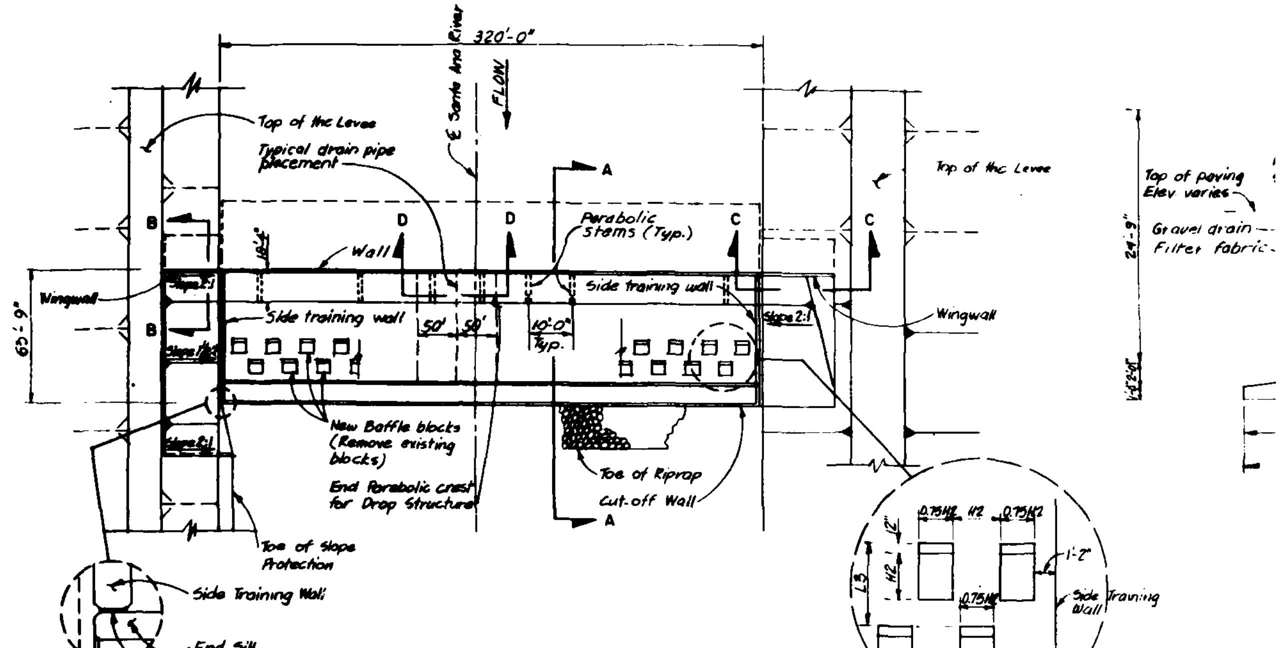
TYPICAL EXISTING CHANNEL IMPROVMENTS

SUBMITTED BY: DATE APPROVED: DISTRICT FILE NO.

SHEET 67 OF 108 SHEETS

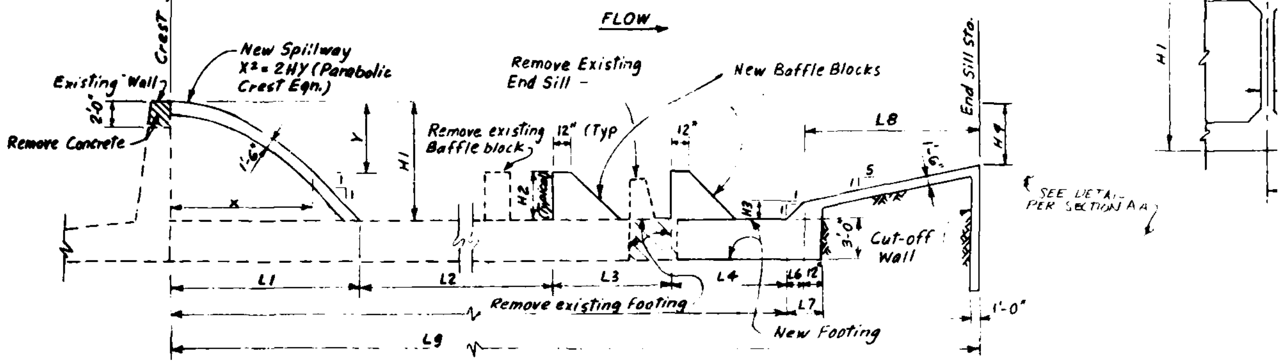
PLATE 70

2

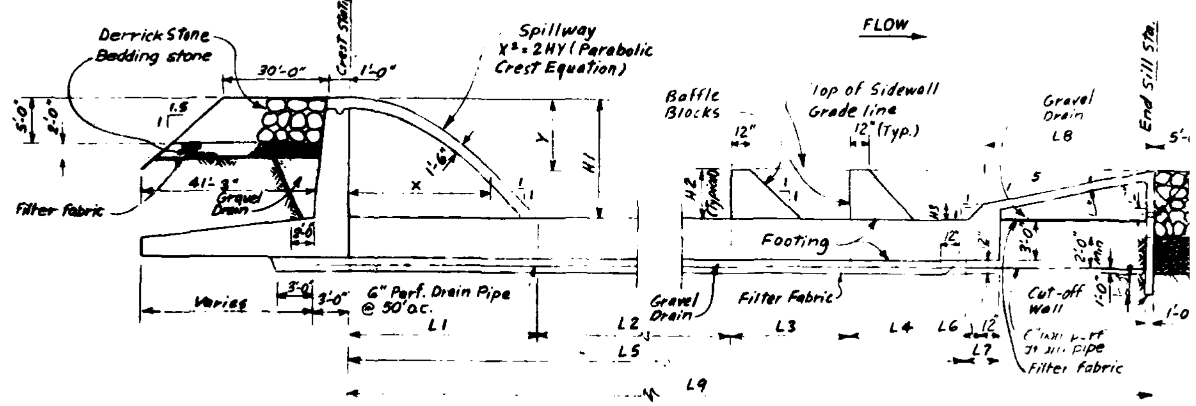


DROP STRUCTURE PLAN
NOT TO SCALE

NOTE:
Sta. 849+40 Shown, others similar.

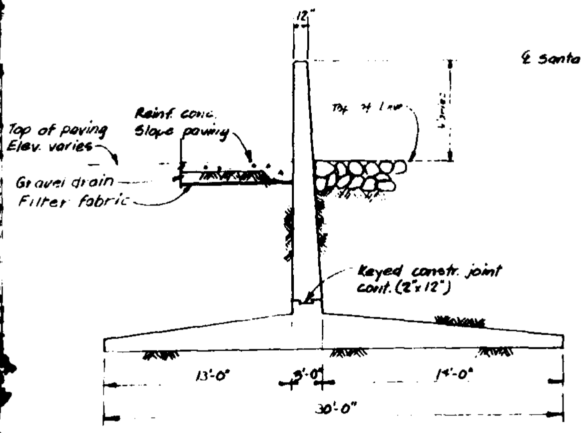


MODIFIED EXISTING DROP STRUCTURE SECTION A-A
STA.601+25 THROUGH STA.1203+00
FOR DRAINAGE SEE THE DRAWING BELOW
NOT TO SCALE

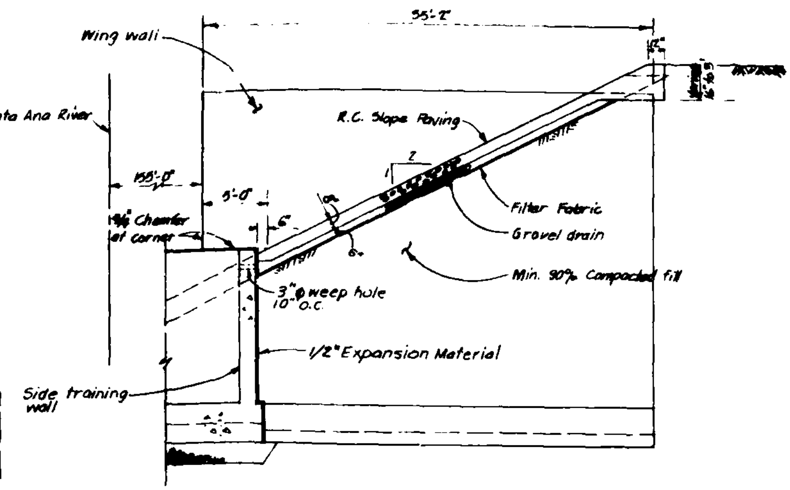


DROP STRUCTURE SECTION A-A
STA.1156+30 AND STA.1106+30 ONLY
NOT TO SCALE

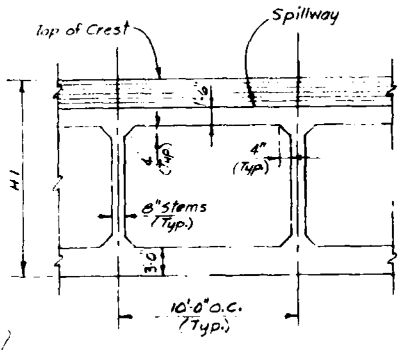
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



WINGWALL SECTION B-B
NOT TO SCALE



SECTION C-C
NOT TO SCALE

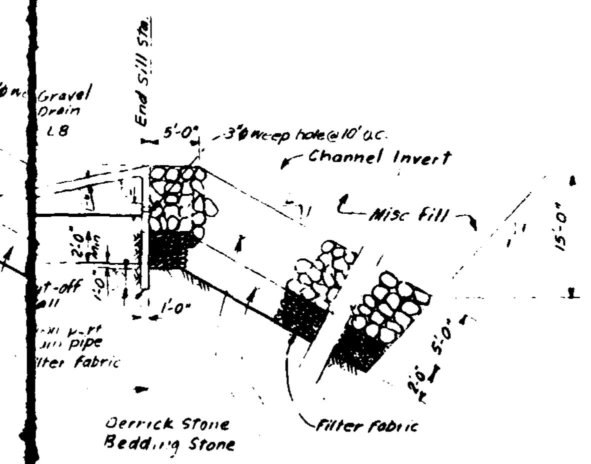


SECTION D-D
NOT TO SCALE

DROP STRUCTURE DIMENSIONS

EXISTING STATION OF CREST	TRANSVERSE SLOPING CREST *	℄ ELEV. OF NEW CREST	L1	L2	L3	L4	L5	L6	L7	L8	L9	H1	H2	H3	W	X	Y	DROP HEIGHT CREST TO END SILL (H4)
1203+12	NO	313.58	12.7	10.0	8.5	8.5	58.7	2.2	3.2	0	62.0	6.74	4.4	2.2	11.20	11.70	5.00	4.50
1031+70	YES	263.07	14.4	10.0	8.05	8.05	54.2	2.1	3.1	8.04	63.24	8.5	4.15	2.1	11.20	11.70	5.00	5.01
977+00	YES	247.20	14.4	10.0	8.05	8.05	54.2	2.1	3.1	8.43	62.33	8.5	4.15	2.1	11.70	11.70	5.00	5.11
914+85	YES	220.43	15.7	20.4	10.2	10.2	58.5	2.0	3.0	9.43	67.83	9.83	4.8	2.0	11.70	11.70	5.00	5.94
881+00	YES	217.40	12.9	18.1	8.8	8.8	51.2	2.2	3.2	3.48	56.88	7.0	4.4	2.2	11.70	11.70	5.00	4.10
844+40	YES	202.00	10.30	21.76	10.07	10.07	61.79	1.94	3.55	2.77	63.73	12.25	3.88	1.94	12.10	12.10	6.05	9.76
811+40	YES	187.00	10.30	21.76	10.07	10.07	61.79	1.94	3.55	2.78	63.73	12.25	3.88	1.94	12.10	12.10	6.05	9.76
745+40	YES	184.18	10.30	21.76	10.07	10.07	61.79	1.94	3.55	2.88	63.73	12.25	3.88	1.94	12.10	12.10	6.05	9.76
680+85	NO	143.00	17.15	23.90	11.75	11.75	84.15	2.45	3.35	2.95	66.80	10.20	4.9	2.45	13.9	13.9	6.95	7.67
644+85	NO	128.30	17.45	23.8	11.8	11.8	84.65	2.4	3.4	3.05	70.1	10.5	4.8	2.4	13.9	13.9	6.95	7.40
601+25	NO	113.40	17.1	23.8	11.9	11.8	84.7	2.5	3.5	2.33	68.53	10.0	5.0	2.5	14.10	14.10	7.05	7.03
NEW STA. OF DROP STRUCTURES	**TRANSVERSE SLOPING CREST ***	**℄ ELEV. OF NEW CREST**	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**L9**	**H1**	**H2**	**H3**	**W**	**X**	**Y**	**H4**
1150+30	NO	301.0	15.7	21.2	10.6	10.6	58.1	2.15	3.15	1.88	61.85	8.5	4.3	2.15	12.41	12.41	6.21	7.03
1100+30	NO	285.5	15.7	21.2	10.6	10.6	58.1	2.15	3.15	1.43	61.00	8.5	4.3	2.15	12.41	12.41	6.21	7.06

* NOTE: CREST OF EXISTING DROP IS 1.0 ft. LOWER ON THE RIGHT BANK.



SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

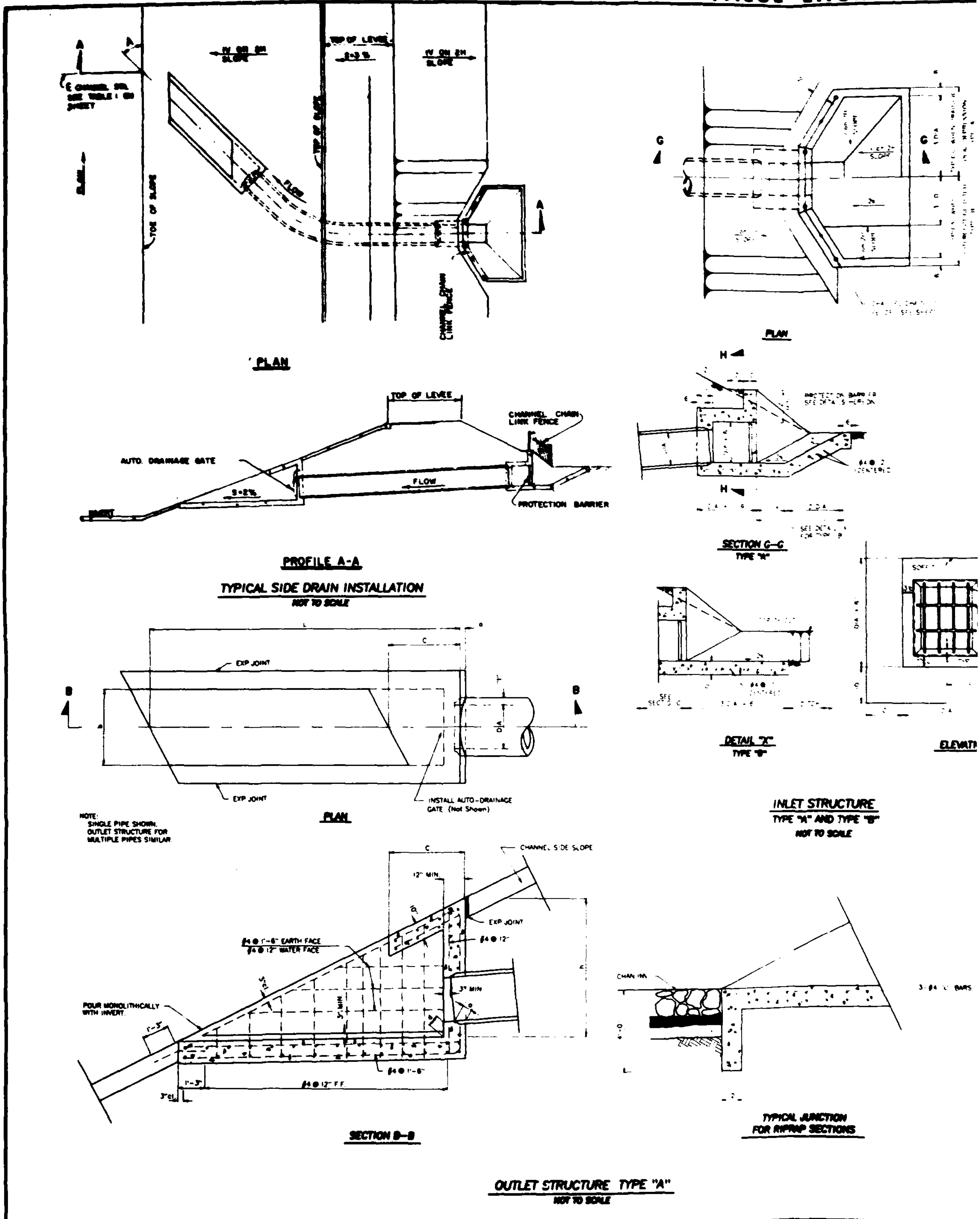
DESIGNED BY:
DRAWN BY: D. VILPPU
P. PENEUETA
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER CHANNEL
DROP STRUCTURE
STRUCTURAL
PLANS AND DETAILS

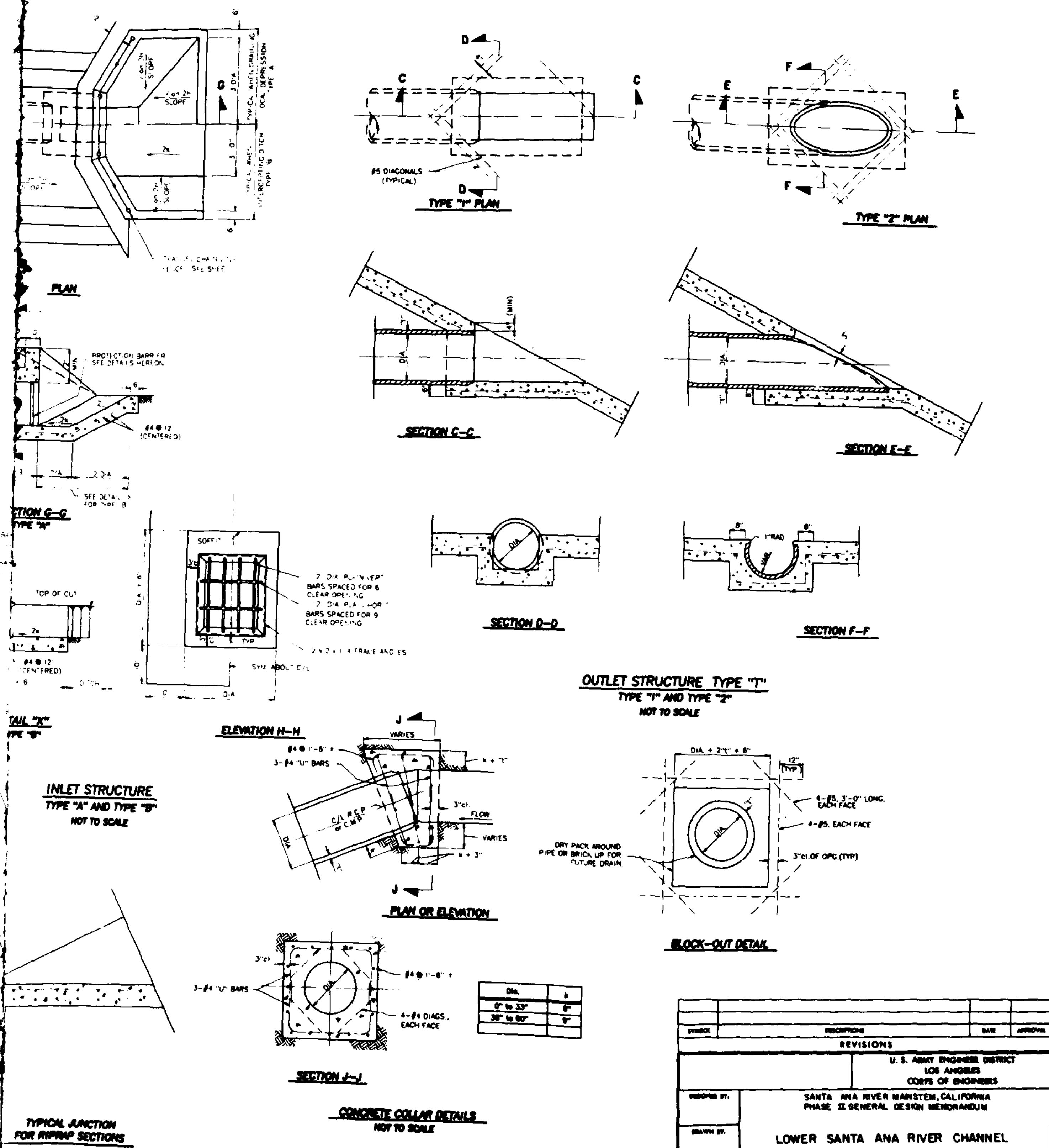
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 88 OF 106 SHEETS

PLATE 71

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



ALUE ENGINEERING PAYS



Dia.	k
0" to 33"	6"
36" to 60"	9"

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL

SIDE DRAINS

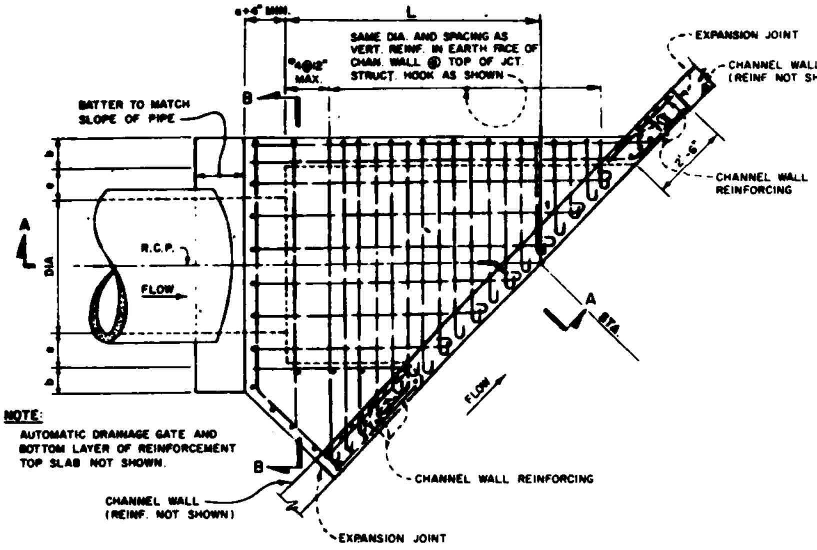
DISTRICT FILE NO.

SHEET 69 OF 106 SHEETS

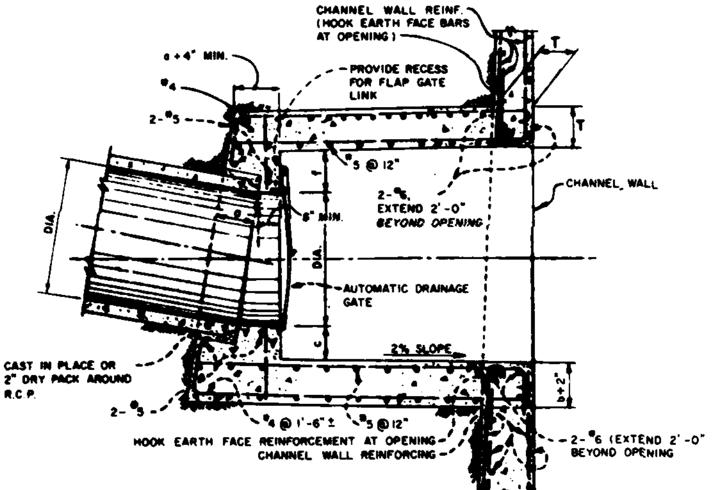
PLATE 72

SAFETY PAYS

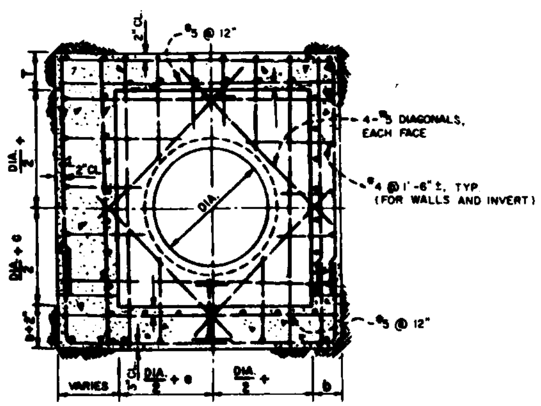
2



PLAN-TOP SLAB



SECTION A-A



NOTE:
AUTOMATIC DRAINAGE GATE NOT SHOWN.

SECTION B-B

JUNCTION STRUCTURE "D"

DRAIN NO.	STATION	SHT_NO.	BANK	PIPE SIZE	PIPE TYPE	PIPE ADG	STRUCTURE INLET TYPE	STRUCTURE OUTLET TYPE
14	1211+10	9	•	8'x9.5'	R.C.B.	no	A	A
1	1207+10	10	RIGHT	14'x9.5'	R.C.B.	no	–	A
2	1202+60	10	RIGHT	66"	R.C.P.	Flap	–	A
15	1202+20	10	LEFT	8'x8'	R.C.B.	no	–	A
15A	1201+90	10	LEFT	24"	R.C.P.	Flap	–	A
2A	1200+75	10	RIGHT	48"	C.M.P.	Flap	–	A
3	1190+08	10	RIGHT	72"	C.M.P.	Flap	–	A
4	1190+00	10	RIGHT	72"	C.M.P.	Flap	–	A
5	1187+10	10	RIGHT	48"	C.M.P.	Flap	–	A
6	1185+18	10	RIGHT	48"	C.M.P.	Flap	–	A
16	1184+68	10	LEFT	60"	R.C.P.	Flap	–	A
16A	1184+47	10	LEFT	24"	R.C.P.	Flap	A	A
7	1184+40	10	RIGHT	48"	C.M.P.	Flap	–	A
8	1184+20	10	RIGHT	48"	C.M.P.	Flap	–	A
9	1183+50	10	RIGHT	48"	C.M.P.	Flap	–	A
10	1183+20	10	RIGHT	48"	C.M.P.	Flap	–	A
11	1182+00	11	RIGHT	48"	C.M.P.	Flap	–	A
12	1181+45	11	RIGHT	48"	C.M.P.	Flap	–	A
13	1181+05	11	RIGHT	19'X8.5'	R.C.B.	no	–	A
28	1177+75	11	RIGHT	48"	C.M.P.	Flap	–	A
17	1172+05	11	LEFT	24"	R.C.P.	Flap	–	A
29	1169+20	11	RIGHT	72"	C.M.P.	Flap	–	A
30	1169+10	11	RIGHT	72"	C.M.P.	Flap	–	A
18	1166+80	11	LEFT	24"	R.C.P.	Flap	–	A
19	1163+10	11	LEFT	8'x5'	R.C.B. x 2	no	–	A
20	1158+08	11	LEFT	6'x5'	R.C.B. x 2	no	–	A
21	1154+57	11	LEFT	24"	R.C.P.	Flap	–	A
22	1151+10	12	LEFT	24"	R.C.P.	Flap	–	A
31	1149+23	12	RIGHT	24"	R.C.P.	Flap	–	A
32	1149+12	12	RIGHT	102"	R.C.P.	Flap	–	A
33	1146+70	12	RIGHT	66"	C.M.P.	Flap	A	A
23	1146+10	12	LEFT	24"	R.C.P.	Flap	–	A
34	1141+20	12	RIGHT	72"	R.C.P.	Flap	–	A
24	1134+92	12	LEFT	8'x6'	R.C.B.	no	–	A
24A	1134+84	12	LEFT	48"	R.C.P.	Flap	A	A
40	1130+78	12	RIGHT	72"	R.C.P.	Flap	–	A
41	1130+70	12	RIGHT	42"	R.C.P.	Flap	–	A
36	1125+15	12	RIGHT	66"	C.M.P.	Flap	A	A
25	1124+60	12	LEFT	24"	R.C.P.	Flap	–	A
42A	1117+00	13	RIGHT	60"	R.C.P.	Flap	–	A
42	1116+90	13	RIGHT	84"	R.C.P.	Flap	–	A
26	1115+10	13	LEFT	8'x8'	R.C.B. x 2	no	–	A
37	1114+40	13	RIGHT	66"	C.M.P.	Flap	A	A
35	1114+13	13	RIGHT	39"	R.C.P.	Flap	–	A
27	1106+07	13	LEFT	24"	R.C.P.	Flap	–	A
38	1099+43	13	RIGHT	54"	R.C.P.	Flap	–	A
45	1096+35	13	LEFT	12'x7'	R.C.B. x 3	no	–	A
39	1095+60	13	RIGHT	84"	C.M.P. x 3	Flap	A	A
43	1076+40	14	RIGHT	36"	R.C.P.	Flap	–	A
44	1075+70	14	RIGHT	54"	R.C.P.	Flap	–	A
46A	1075+03	14	LEFT	8'x7'	R.C.B.	no	A	A
46	1074+80	14	LEFT	8'x7'	R.C.B. x 3	no	A	A
49	1066+60	14	RIGHT	8'x6'	R.C.B.	no	–	A
47	1065+85	14	LEFT	24"	R.C.P.	Flap	–	A
48	1062+15	15	LEFT	48"	R.C.P.	Flap	–	A
50	1059+90	15	RIGHT	20'x11.5'	R.C.B.	no	–	A
51	1046+70	15	LEFT	60"	R.C.P.	Flap	–	A
51A	1046+50	15	LEFT	60"	R.C.P.	Flap	A	A
60	1045+85	15	RIGHT	30"	R.C.P.	Flap	–	A
52	1037+95	15	LEFT	60"	R.C.P.	Flap	–	A
61	1032+40	16	RIGHT	36"	C.M.P. x 3	Slide	A	X
62	1031+30	16	RIGHT	36"	C.M.P. x 4	no	–	–
53	1029+15	16	LEFT	54"	R.C.P.	Flap	–	A
53A	1029+10	16	LEFT	42"	R.C.P.	Flap	A	A
54	1021+95	16	LEFT	24"	C.M.P.	Flap	–	A
63	1018+95	16	RIGHT	72"	R.C.P.	Flap	–	A
64	1018+85	16	RIGHT	36"	R.C.P.	Flap	–	A
55	1013+60	16	LEFT	24"	C.M.P.	Flap	–	A
56	1007+40	16	LEFT	54"	R.C.P. x 4	Flap	–	A
57	994+80	17	LEFT	60"	R.C.P. x 2	Flap	–	A
57A	994+53	17	LEFT	36"	R.C.P.	Flap	–	A
57B	994+45	17	LEFT	72"	R.C.P.	Flap	A	A
58	992+15	17	LEFT	30"	C.M.P. x 2	Flap	–	A
59	984+55	17	LEFT	48"	R.C.P.	Flap	–	A
65	979+35	17	RIGHT	36"	C.M.P. x 4	Slide	A	X
66	978+40	17	LEFT	48"	R.C.P.	Flap	–	A
67	975+65	17	LEFT	18"	R.C.P.	Flap	–	A
68	970+90	18	LEFT	24"	R.C.P.	Flap	–	A
69	965+90	18	LEFT	10'x6'	R.C.B.	no	–	A
70	948+60	18	LEFT	48"	C.M.P.	Flap	–	A
71	947+20	18	LEFT	30"	C.M.P.	Flap	–	A
73	940+20	19	LEFT	42"	R.C.P.	Flap	–	A
73A	940+15	19	LEFT	24"	R.C.P.	Flap	A	A
74A	928+70	19	LEFT	54"	R.C.P.	Flap	A	A
74	928+55	19	LEFT	54"	R.C.P.	Flap	–	A
74B	927+40	19	LEFT	54"	R.C.P.	Flap	–	A
76	926+20	19	LEFT	60"	C.M.P.	Flap	–	A
77	923+70	19	LEFT	36"	R.C.P.	Flap	–	A
78	923+05	19	LEFT	18"	R.C.P.	Flap	–	A
75	916+20	19	RIGHT	24"	C.M.P. x 2	Slide	A	X
79	907+80	20	LEFT	48"	R.C.P. x 2	Flap	–	A
80	898+00	20	LEFT	48"	R.C.P. x 2	Flap	–	A
82	893+90	20	RIGHT	24"	C.M.P. x 4	Slide	A	X
81	871+20	21	LEFT	60"	C.M.P.	Flap	–	A
155	857+80	21	LEFT	18"	R.C.P.	Flap	–	A
83	853+70	22	RIGHT	36"	C.M.P.	no	–	–
84	846+25	22	RIGHT	CARBON CREEK CHANNEL				
86	845+40	22	RIGHT	36"	C.M.P. x 4	Slide	A	X
85	844+50	22	RIGHT	36"	C.M.P. x 4	no	–	–
94	829+70	22	LEFT	24"	C.M.P.	Flap	–	A
87	813+20	23	RIGHT	36"	C.M.P. x 2	Slide	A	X
89	804+80	23	LEFT	30"	R.C.P.	Flap	–	A
90	801+20	23	LEFT	36"	C.M.P.	Flap	–	A
91	797+35	23	LEFT	42"	R.C.P.	Flap	–	A
92	788+10	24	LEFT	7'x7'	R.C.B. x 2	no	A	A

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

BANK	PIPE SIZE	PIPE TYPE	PIPE ADG	STRUCTURE INLET TYPE	STRUCTURE OUTLET TYPE	CONC. COLLAR
E·	9'x9.5'	R.C.B.	no	A	A	no
IGHT	14'x9.5'	R.C.B.	no	–	A	yes
IGHT	66"	R.C.P.	Flap	–	A	yes
EFT	8'x8'	R.C.B.	no	–	A	yes
EFT	24"	R.C.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	72"	C.M.P.	Flap	–	A	yes
IGHT	72"	C.M.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
EFT	60"	R.C.P.	Flap	–	A	yes
EFT	24"	R.C.P.	Flap	A	A	no
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
IGHT	19'X8.5'	R.C.B.	no	–	A	yes
IGHT	48"	C.M.P.	Flap	–	A	yes
EFT	24"	R.C.P.	Flap	–	A	yes
IGHT	72"	C.M.P.	Flap	–	A	yes
IGHT	72"	C.M.P.	Flap	–	A	yes
EFT	24"	R.C.P.	Flap	–	A	yes
EFT	8'x5'	R.C.B. x 2	no	–	A	yes
EFT	6'x5'	R.C.B. x 2	no	–	A	yes
EFT	24"	R.C.P.	Flap	–	A	yes
T	24"	R.C.P.	Flap	–	A	yes
GHT	24"	R.C.P.	Flap	–	A	yes
HT	102"	R.C.P.	Flap	–	A	yes
GHT	66"	C.M.P.	Flap	A	A	no
EFT	24"	R.C.P.	Flap	–	A	yes
GHT	72"	R.C.P.	Flap	–	A	yes
EFT	8'x6'	R.C.B.	no	–	A	yes
EFT	48"	R.C.P.	Flap	A	A	no
IGHT	72"	R.C.P.	Flap	–	A	yes
GHT	42"	R.C.P.	Flap	–	A	yes
IGHT	66"	C.M.P.	Flap	A	A	no
EFT	24"	R.C.P.	Flap	–	A	yes
IGHT	60"	R.C.P.	Flap	–	A	yes
GHT	84"	R.C.P.	Flap	–	A	yes
EFT	8'x8'	R.C.B. x 2	no	–	A	yes
IGHT	66"	C.M.P.	Flap	A	A	no
HT	39"	R.C.P.	Flap	–	A	yes
EFT	24"	R.C.P.	Flap	–	A	yes
IGHT	54"	R.C.P.	Flap	–	A	yes
EFT	12'x7'	R.C.B. x 3	no	–	A	yes
IGHT	84"	C.M.P. x 3	Flap	A	A	no
IGHT	36"	R.C.P.	Flap	–	A	yes
IGHT	54"	R.C.P.	Flap	–	A	yes
EFT	8'x7'	R.C.B.	no	A	A	no
EFT	8'x7'	R.C.B. x 3	no	A	A	no
GHT	8'x6'	R.C.B.	no	–	A	yes
EFT	24"	R.C.P.	Flap	–	A	yes
EFT	48"	R.C.P.	Flap	–	A	yes
IGHT	20'x11.5'	R.C.B.	no	–	A	yes
EFT	60"	R.C.P.	Flap	–	A	yes
EFT	60"	R.C.P.	Flap	A	A	no
IGHT	30"	R.C.P.	Flap	–	A	yes
EFT	60"	R.C.P.	Flap	–	A	yes
IGHT	36"	C.M.P. x 3	Slide	A	X	no
IGHT	36"	C.M.P. x 4	no	–	–	no
EFT	54"	R.C.P.	Flap	–	A	yes
EFT	42"	R.C.P.	Flap	A	A	no
EFT	24"	C.M.P.	Flap	–	A	yes
IGHT	72"	R.C.P.	Flap	–	A	yes
IGHT	36"	R.C.P.	Flap	–	A	yes
EFT	24"	C.M.P.	Flap	–	A	yes
EFT	54"	R.C.P. x 4	Flap	–	A	yes
EFT	60"	R.C.P. x 2	Flap	–	A	yes
EFT	36"	R.C.P.	Flap	–	A	yes
EFT	72"	R.C.P.	Flap	A	A	no
EFT	30"	C.M.P. x 2	Flap	–	A	yes
EFT	48"	R.C.P.	Flap	–	A	yes
IGHT	36"	C.M.P. x 4	Slide	A	X	no
EFT	48"	R.C.P.	Flap	–	A	yes
EFT	18"	R.C.P.	Flap	–	A	yes
EFT	24"	R.C.P.	Flap	–	A	yes
EFT	10'x6'	R.C.B.	no	–	A	yes
EFT	48"	C.M.P.	Flap	–	A	yes
EFT	30"	C.M.P.	Flap	–	A	yes
EFT	42"	R.C.P.	Flap	–	A	yes
EFT	24"	R.C.P.	Flap	A	A	no
EFT	54"	R.C.P.	Flap	A	A	no
EFT	54"	R.C.P.	Flap	–	A	yes
EFT	54"	R.C.P.	Flap	–	A	yes
EFT	60"	C.M.P.	Flap	–	A	yes
EFT	36"	R.C.P.	Flap	–	A	yes
EFT	18"	R.C.P.	Flap	–	A	yes
IGHT	24"	C.M.P. x 2	Slide	A	X	no
EFT	48"	R.C.P. x 2	Flap	–	A	yes
EFT	48"	R.C.P. x 2	Flap	–	A	yes
IGHT	24"	C.M.P. x 4	Slide	A	X	no
EFT	60"	C.M.P.	Flap	–	A	yes
EFT	18"	R.C.P.	Flap	–	A	yes
IGHT	36"	C.M.P.	no	–	–	no
GHT	CARBON CREEK CHANNEL					
IGHT	36"	C.M.P. x 4	Slide	A	X	no
GHT	36"	C.M.P. x 4	no	–	–	no
EFT	24"	C.M.P.	Flap	–	A	yes
IGHT	36"	C.M.P. x 2	Slide	A	X	no
EFT	30"	R.C.P.	Flap	–	A	yes
EFT	36"	C.M.P.	Flap	–	A	yes
EFT	42"	R.C.P.	Flap	–	A	yes
EFT	7'x7'	R.C.B. x 2	no	A	A	no

DRAIN NO.	STATION	SHT_NO.	BANK	PIPE SIZE	PIPE TYPE	PIPE ADG	STRUCTURE INLET TYPE	STRUCTURE OUTLET TYPE	CONC. COLLAR
93	763+30	25	LEFT	66"	R.C.P.	Flap	–	A	yes
156	753+85	25	RIGHT	36"	C.M.P.	Flap	–	A	yes
95	750+30	25	LEFT	16"	C.M.P.	Flap	–	A	yes
96	748+10	25	LEFT	54"	R.C.P.	Flap	–	A	yes
100	747+90	25	RIGHT	12'x9.5'	R.C.B.	no	A	A	no
97	740+35	25	LEFT	48"	R.C.P.	Flap	–	A	yes
102	735+12	25	RIGHT	12'x12'	R.C.B.	no	A	A	no
98	724+80	26	LEFT	14"	A.C.P.	no	–	T2	yes
88B	714+35	26	RIGHT	30"	C.M.P.	Flap	–	A	yes
99	709+80	26	LEFT	48"	R.C.P.	Flap	–	A	yes
88A	709+30	26	RIGHT	48"	R.C.P.	Flap	A	A	no
88	708+60	26	RIGHT	42"	R.C.P.	Flap	–	A	yes
157	703+20	27	RIGHT	18"	R.C.P.	Flap	–	A	yes
101	697+50	27	LEFT	12'x12'	R.C.B. x 2	no	A	A	no
105	695+70	27	LEFT	48"	R.C.P.	Flap	–	A	yes
105A	695+50	27	LEFT	30"	C.M.P.	Flap	–	A	yes
103A	690+33	27	RIGHT	18"	R.C.P.	Flap	–	A	yes
103	689+45	27	RIGHT	42"	C.M.P.	Flap	–	A	yes
104A	687+90	27	RIGHT	18"	R.C.P.	Flap	–	A	yes
104	686+72	27	RIGHT	48"	R.C.P.	Flap	–	A	yes
106	682+40	27	LEFT	24"	R.C.P.	Flap	–	A	yes
107	669+98	28	LEFT	48"	R.C.P.	Flap	–	A	yes
158	664+55	28	RIGHT	18"	C.M.P.	Flap	–	A	yes
159	662+10	28	RIGHT	18"	C.M.P.	Flap	–	A	yes
108	659+00	28	LEFT	48"	R.C.P.	Flap	–	A	yes
109	654+40	28	LEFT	18"	C.M.P.	Flap	–	A	yes
115	643+50	29	RIGHT	10'x11'	R.C.B.	no	–	A	yes
115A	639+62	29	RIGHT	24"	PIPE	Flap	A	A	no
110	627+20	29	LEFT	BUTTERBUSH CHANNEL					
116	627+10	29	RIGHT	30"	R.C.P. x 2	Flap	–	A	yes
111	627+00	29	LEFT	48"	R.C.P.	Flap	–	A	yes
116A	626+95	29	RIGHT	12"	C.M.P.	Flap	A	A	no
112	625+75	29	LEFT	5'x5'	R.C.B. x 3	no	–	A	yes
113	621+80	29	LEFT	3'x6'	R.C.B. x 6	no	–	A	yes
117	620+60	29	RIGHT	42"	R.C.P.	Flap	–	A	yes
117A	618+20	29	RIGHT	36"	R.C.P.	Flap	–	A	yes
160	613+38	30	RIGHT	18"	R.C.P.	Flap	–	A	yes
119	607+50	30	RIGHT	24"	R.C.P.	Flap	–	A	yes
118	607+23	30	RIGHT	42"	R.C.P.	Flap	–	A	yes
119A	605+60	30	RIGHT	24"	R.C.P.	Flap	A	A	no
114	605+10	30	LEFT	24"	C.M.P.	Flap	–	A	yes
120	600+80	30	RIGHT	36"	R.C.P.	Flap	–	A	yes
121	600+10	30	RIGHT	36"	R.C.P.	Flap	–	A	yes
124A	583+60	30	LEFT	36"	R.C.P.	Flap	A	A	no
124	583+55	30	LEFT	24"	R.C.P.	Flap	–	A	yes
123	583+10	31	RIGHT	30"	R.C.P.	Flap	–	A	yes
122	583+00	31	RIGHT	54"	R.C.P.	Flap	–	A	yes
125	562+60	31	LEFT	SANTIAGO CREEK CHANNEL					
126	560+90	31	RIGHT	48"	R.C.P.	Flap	–	A	yes
126A	560+85	31	RIGHT	48"	R.C.P.	Flap	–	A	yes
133	554+90	31	LEFT	24"	R.C.P.	no	–	T1	yes
127	554+40	31	RIGHT	30"	C.M.P.	Flap	–	A	yes
128	536+75	32	RIGHT	36"	C.M.P.	Flap	–	A	yes
128A	536+07	32	RIGHT	24"	R.C.P.	no	A	T1	no
134	535+00	32	LEFT	58"x36"	ARCH	no	–	A	yes
135	534+55	32	LEFT	30"	PIPE	no	–	T1	yes
129	531+30	32	RIGHT	36"	R.C.P.	Flap	–	A	yes
136	530+80	32	LEFT	30"	PIPE	no	–	T1	yes
137A	523+60	32	LEFT	24"	PIPE	no	A	T1	no
137	523+20	33	LEFT	48"	R.C.P. x 3	Flap	–	A	yes
130	522+00	33	RIGHT	36"	R.C.P.	Flap	–	A	yes
131A	508+90	33	RIGHT	36"	R.C.P.	Flap	A	A	no
131	508+70	[illegible]	[illegible]	60"	R.C.P.	Flap	–	A	yes
138	503+80	33	LEFT	10'x5'4"	R.C.B. x 2	no	–	A	yes
132	499+80	33	RIGHT	36"	P.C.P.	Flap	–	A	yes
139	490+00	34	LEFT	60"	R.C.P.	Flap	–	A	yes
139A	489+75	34	LEFT	18"	R.C.P.	no	–	T2	yes
161	460+30	35	LEFT	12"	C.M.P.	no	–	T1	yes
140A	399+70	37	RIGHT	18"	R.C.P.	no	A	T2	no
140	399+50	37	RIGHT	30"	R.C.P.	Flap	–	T1	yes
141	353+30	38	RIGHT	24"	PIPE x 2	Flap	–	A	yes
142	352+50	38	RIGHT	60"	R.C.P.	Flap	–	A	yes
162	277+10	41	RIGHT	12"	PIPE	no	–	T2	yes
163	229+90	51	LEFT	•	PIPE	no	–	A	yes
164	229+30	51	LEFT	•	PIPE x 2	no	–	A	yes
165	212+00	52	LEFT	•	PIPE x 2	no	–	A	yes
143	208+10	43	RIGHT	24"	PIPE	Flap	–	D	yes
146	190+50	53	LEFT	42"	R.C.P.	no	–	See Note 2	yes
147	182+60	53	LEFT	42"	R.C.P.	no	–	See Note 2	yes
148	174+60	53	LEFT	42"	R.C.P.	no	–	See Note 2	yes
166	173+30	53	LEFT	42"	PIPE	no	–	See Note 2	yes
149	165+90	53	LEFT	36"	R.C.P.	no	–	See Note 2	yes
150	159+80	54	LEFT	30"	R.C.P.	no	–	See Note 2	yes
144	159+20	45	RIGHT	36"	R.C.P. x 3	Flap	–	D	yes
167	156+80	54	LEFT	24"	STEEL x 3	Flap	A	D	no
151	150+32	45	LEFT	FAIRVIEW CHANNEL					
145	90+80	47	RIGHT	42"	R.C.P. x 4	Flap	–	A	yes
152	76+40	47	LEFT	GREENVILLE–BANNING CHANNEL					
153	17+90	50	LEFT	60"	R.C.P.	–	–	See Note 4	
154	15+90	50	LEFT	45"	R.C.P.	Flap	–	A	yes

NOTES:
1. TYPE "X" STRUCTURAL DETAIL TO BE DESIGNED BY OTHERS.
2. JOIN STORM DRAIN PIPE TO NEW MANHOLE AND R.C.P. COLLECTOR SYSTEM.
3. SEE DETAILS ON SHEET 69 FOR INLET AND OUTLET TYPES "A", "B" AND "T"
4. REMOVE EXISTING STRUCTURE AND REPLACE WITH TIDE GATE STRUCTURE. SEE SHEET 82.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

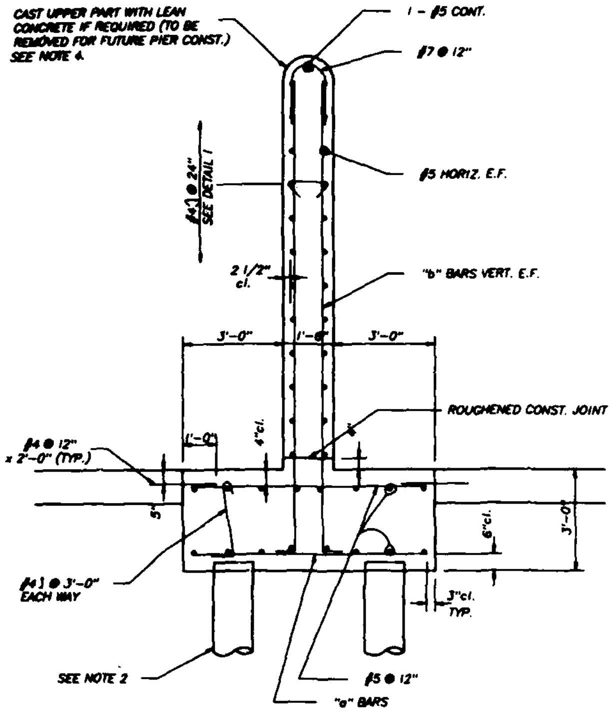
LOWER SANTA ANA RIVER CHANNEL

SIDE DRAINS

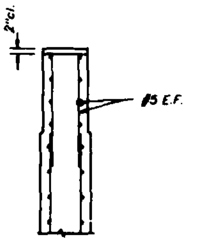
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 70 OF 105 SHEETS

PLATE 73

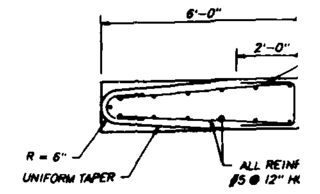
2



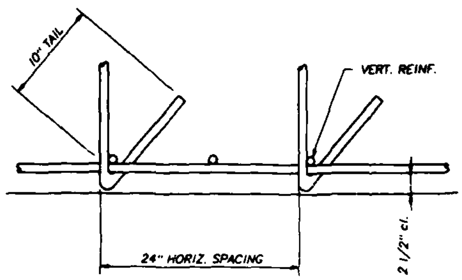
SECTION A-A
1/2 IN. = 1 FT.



SECTION B-B
1/2 IN. = 1 FT.

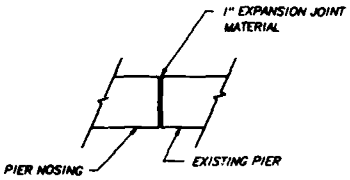


SECTION C-C
1 2 IN. = 1 FT.

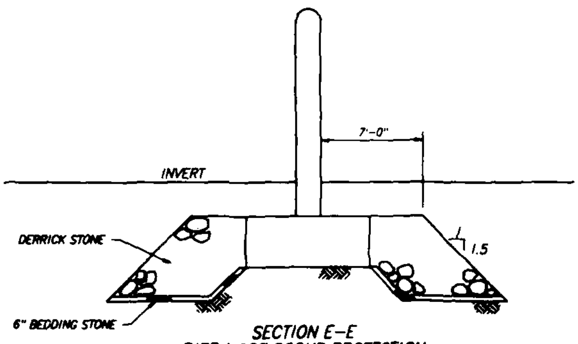


DETAIL I
1 1/2 IN. = 1 FT.

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



SECTION D-D
1/2 IN. = 1 FT.



SECTION E-E
PIER NOSE SCOUR PROTECTION
1/4 IN. = 1 FT.

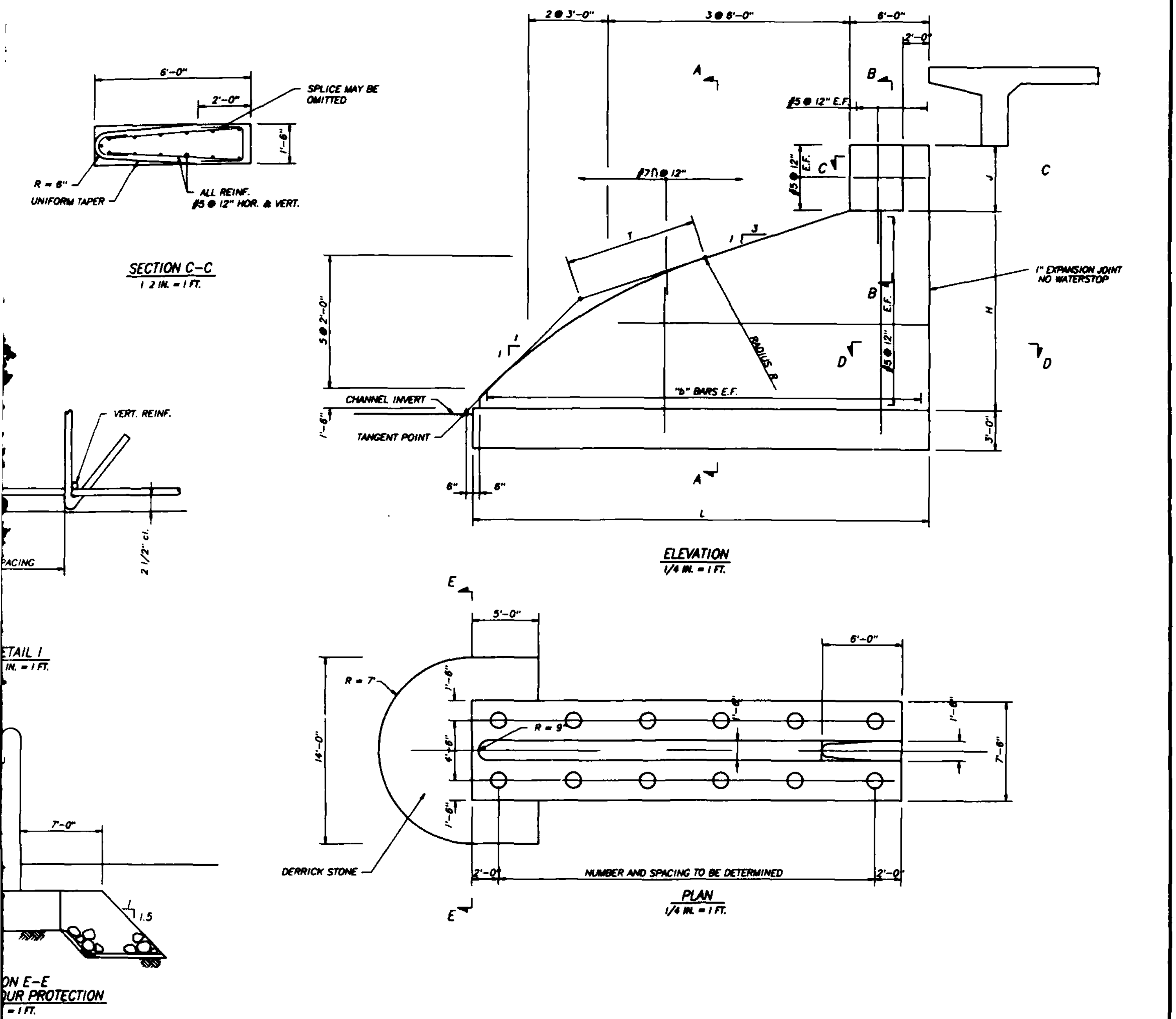
PIER NOSING

LOCATION	STATION	NO. PIER EXTENSIONS	BOTT. FOOTING ELEVATION	SKEW	H	J	L	PILE TIP ELEVATION
PACIFIC COAST HWY.	16+95	2	-11.75	8°43'49"	•	•	•	•
VICTORIA/HAMILTON AVE.	90+40	2	-7.0'	15°45'50"	•	•	•	•
SAN DIEGO FWY.	262+15	3	19.0'	2°42'7"	•	•	•	•
WARNER AVE.	341+30	4	36.9'	9° 4'47"	•	•	•	•
HARBOR BLVD.	349+90	6	42.0'	45° 0' 0"	•	•	•	•
EDINGER AVE.	392+80	4	51.0'	16°30' 0"	•	•	•	•
BOLSA/1ST ST.	459+00	4	66.0'	13°1'25"	•	•	•	•
5TH ST.	473+56	4	71.15'	25°52'47"	•	•	•	•
FAIRVIEW ST.	508+80	5	76.5'	54°18'54"	•	•	•	•
GARDEN GROVE BLVD.	582+91	6	96.5'	7°5'53"	•	•	•	•
GARDEN GROVE FWY.	603+17	5	103.0'	23°18'18"	•	•	•	•
SANTA ANA FWY.	625+39	6	110.6'	25° 0' 0"	•	•	•	•
RIVERSIDE FWY.	926+32	8	226.0'	31° 0' 0"	•	•	•	•

• TO BE DETERMINED LATER

PIER NOSE SCOUR PROTECTION

LOCATION	STATION	NO. PIE NOSES
GARDEN GROVE BLVD.	582+91	6
GARDEN GROVE FWY.	603+17	5
SANTA ANA FWY.	625+39	5
CHAPMAN	638+76	4
ORANGE FWY.	682+32	5
SOUTHERN PACIFIC R.R.	733+25	5
BALL RD.	749+29	5
LINCOLN AVE.	821+45	5
GLASSELL ST.	865+74	6
A.T.& S.F. R.R.	897+80	5
TUSTIN AVE.	918+33	6
RIVERSIDE FWY.	926+32	8
LAKEVIEW AVE.	983+49	5
IMPERIAL HWY.	1065+61	3
WEIR CANYON RD.	1207+19	3



PIER NOSE SCOUR PROTECTION

LOCATION	STATION	NO. PIER NOSES
GARDEN GROVE BLVD.	582+91	6
GARDEN GROVE FWY.	603+17	5
SANTA ANA FWY.	625+39	5
CHAPMAN	638+76	4
ORANGE FWY.	682+32	5
SOUTHERN PACIFIC R.R.	733+25	5
BALL RD.	749+29	5
LINCOLN AVE.	821+45	5
GLASSELL ST.	865+74	6
A.T.& S.F. R.R.	887+80	5
TUSTIN AVE.	918+33	6
RIVERSIDE FWY.	926+32	8
LAKEVIEW AVE.	983+49	5
IMPERIAL HWY.	1065+61	3
WEIR CANYON RD.	1207+19	3

NOTES:

1. TOP OF FOOTING TO CONFORM TO CHANNEL INVERT
2. TOP OF FOOTING SHALL BE 2' MIN. BELOW CHANNEL INVERT IN SOFT-BOTTOM SECTIONS.
3. PILE NUMBER AND SPACING TO BE DETERMINED LATER.
4. BRIDGES REQUIRING EXPANSION TO BE DETERMINED LATER.

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

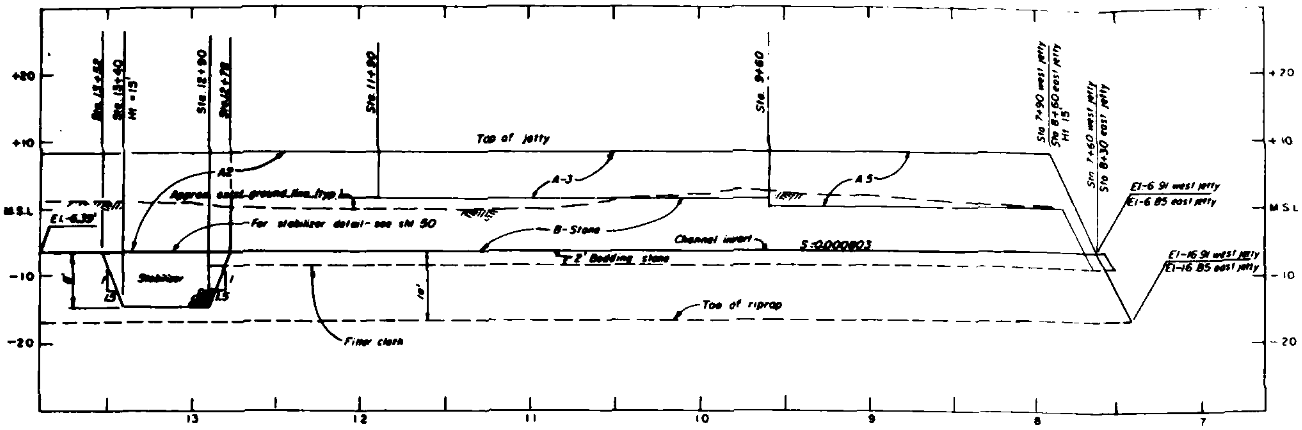
LOWER SANTA ANA RIVER CHANNEL

PIER NOSE TYPICAL

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 71 OF 105 SHEETS

PLATE 70

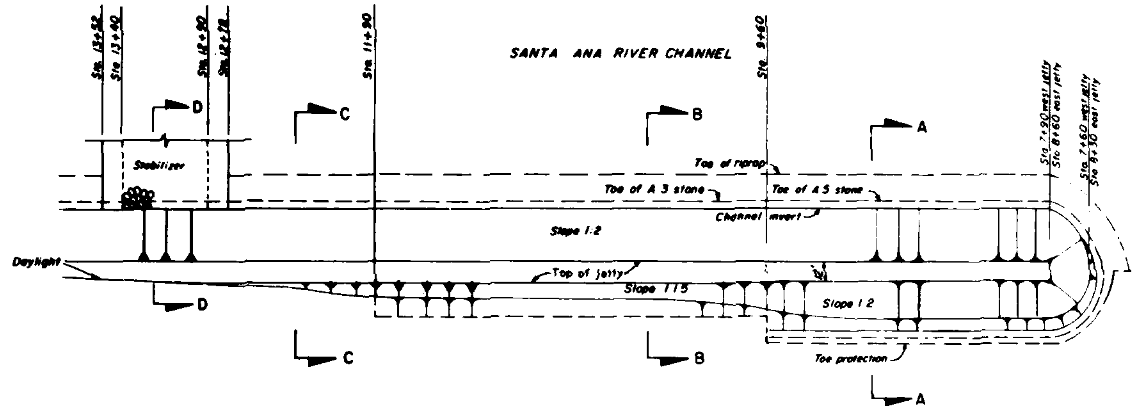
2



PROFILE-SANTA ANA RIVER WEST JETTY

HORIZ SCALE 1 IN = 40 FT
VERT. SCALE 1 IN = 10 FT

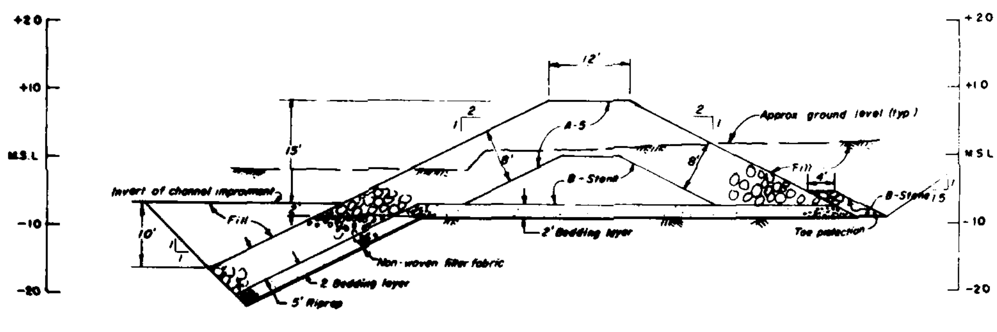
NOTE EAST JETTY SIMILAR
REFER TO SHEET — FOR HYDRAULIC ELEMENTS.



PLAN-SANTA ANA RIVER WEST JETTY

SCALE 1 IN = 40 FT

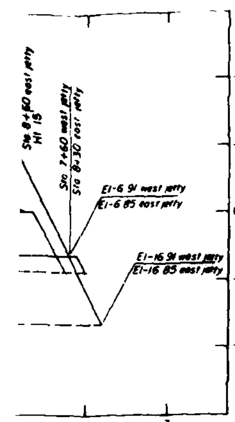
NOTE WEST JETTY SHOWN, EAST JETTY SIMILAR

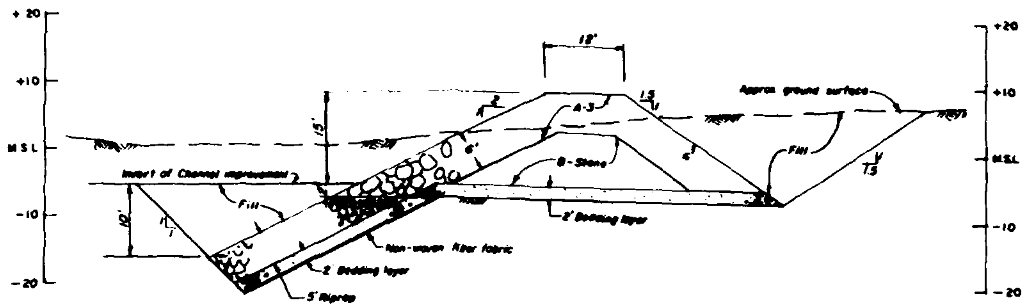


SECTION A-A

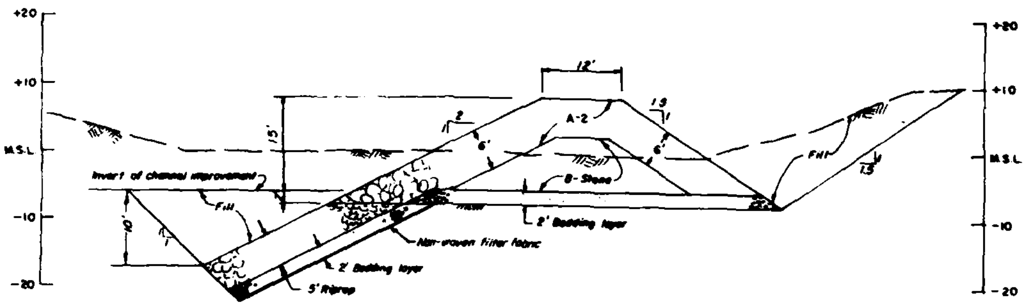
STA 8+60 TO STA 9+60 - WEST JETTY
STA 7+90 TO STA 9+60 - EAST JETTY
SCALE 1 IN = 10 FT.

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

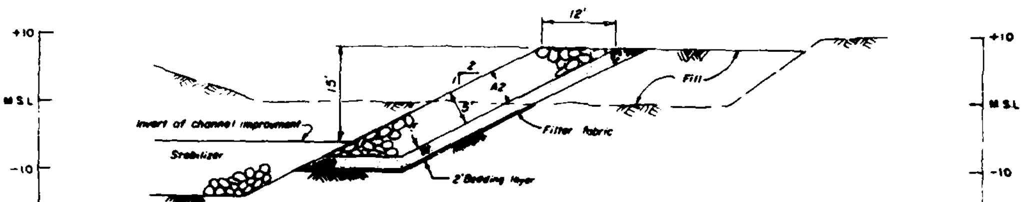




SECTION B-B
STA 9+60 TO STA 11+90

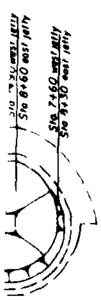


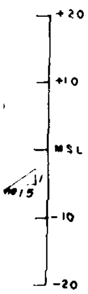
SECTION C-C
STA.11+90 TO STA.12+78



SECTION D-D
STA.12+90 TO STA 13+40

The mean sea level datum (0.0 MSL) equals +2.8 feet
Mean lower low water datum (+2.8 MLLW)





DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: H.M.
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
JETTY CONSTRUCTION

SUBMITTED BY: | DATE APPROVED: | DISTRICT FILE NO.

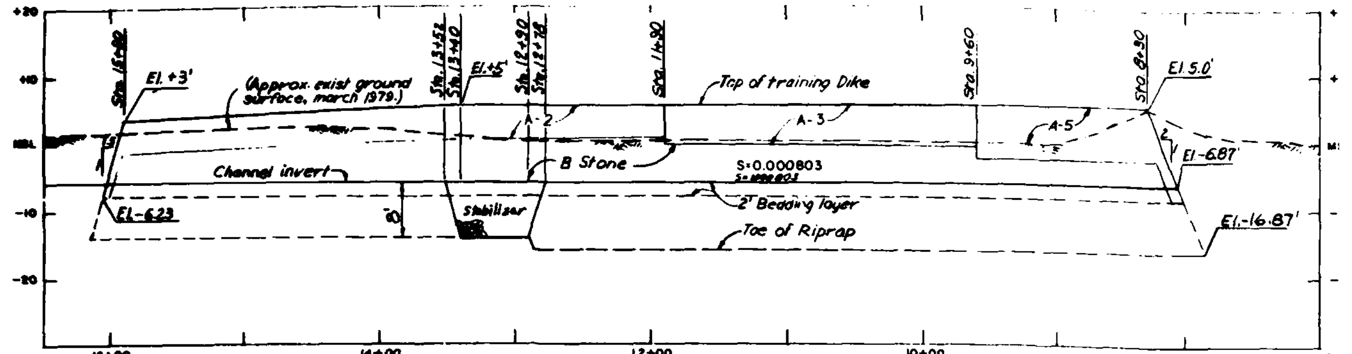
SHEET 72 OF 108 SHEETS

PLATE 75

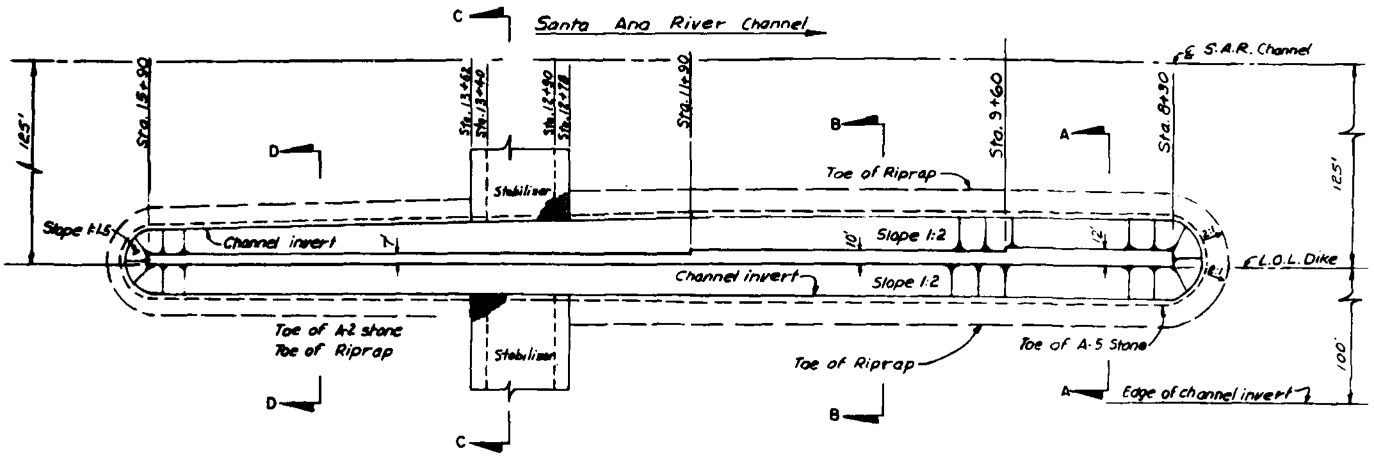
SAFETY PAYS

1

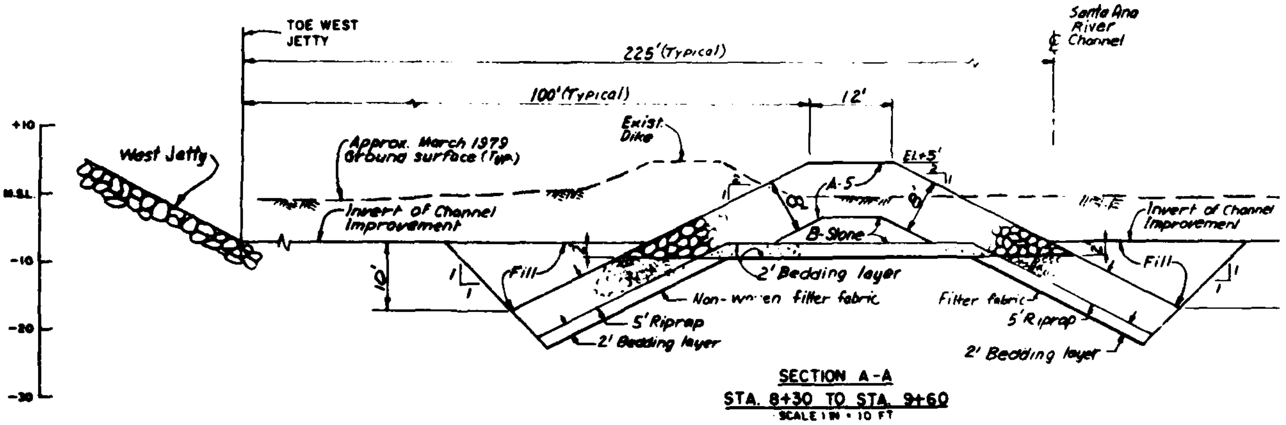
2



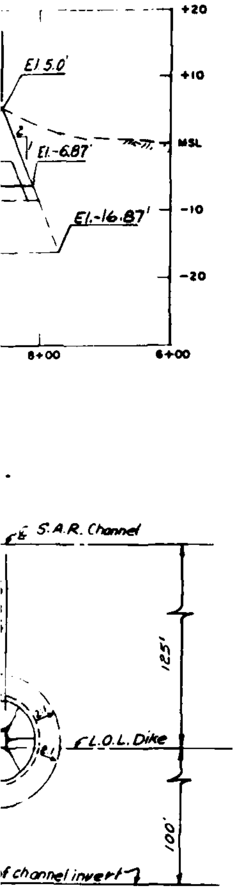
PROFILE-SANTA ANA RIVER DIKE
HORIZ. SCALE: 1 IN. = 50 FT.
VERT. SCALE: 1 IN. = 10 FT.

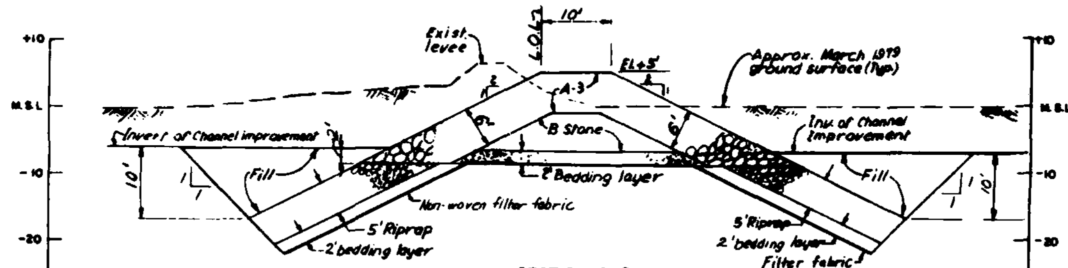


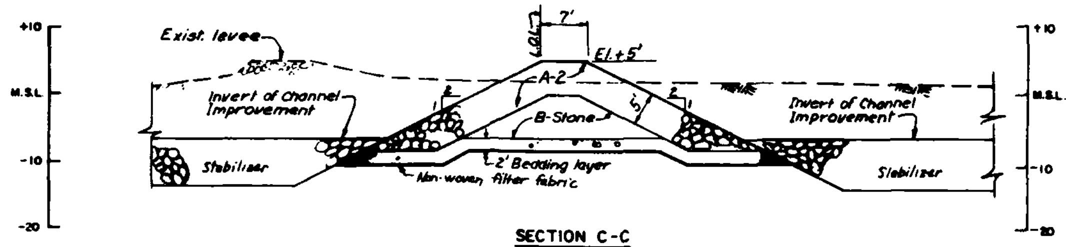
PLAN-SANTA ANA RIVER DIKE
SCALE: 1 IN. = 50 FT.

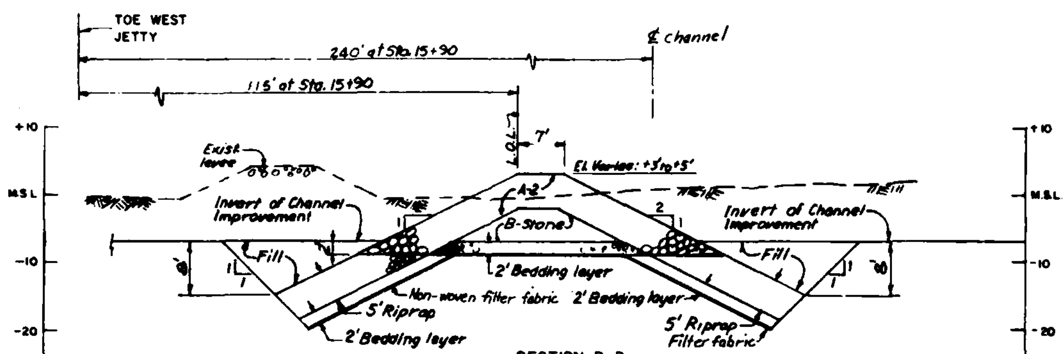


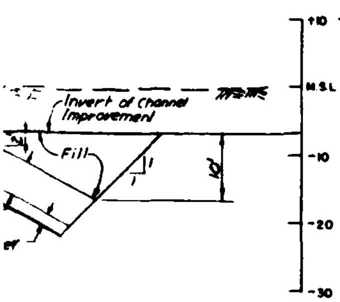
SECTION A-A
STA. 8+30 TO STA. 9+60
SCALE: 1 IN. = 10 FT.




SECTION B B
STA. 9+60 TO STA. 12+78
SCALE: 1 IN = 10 FT


SECTION C-C
STA. 12+90 TO STA. 13+40
SCALE 1 IN. = 10 FT.


SECTION D-D
STA. 13+52 TO STA. 15+90
SCALE: 1 IN. = 10 FT



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: M. B. D. IRPPU
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL

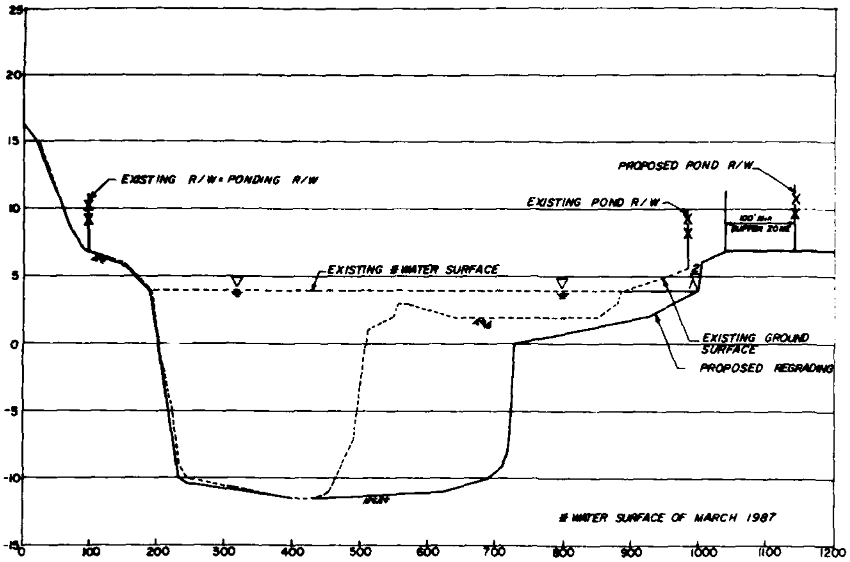
DIKE CONSTRUCTION

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

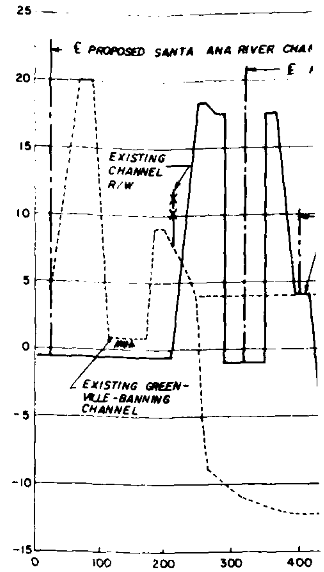
SHEET 73 OF 105 SHEETS

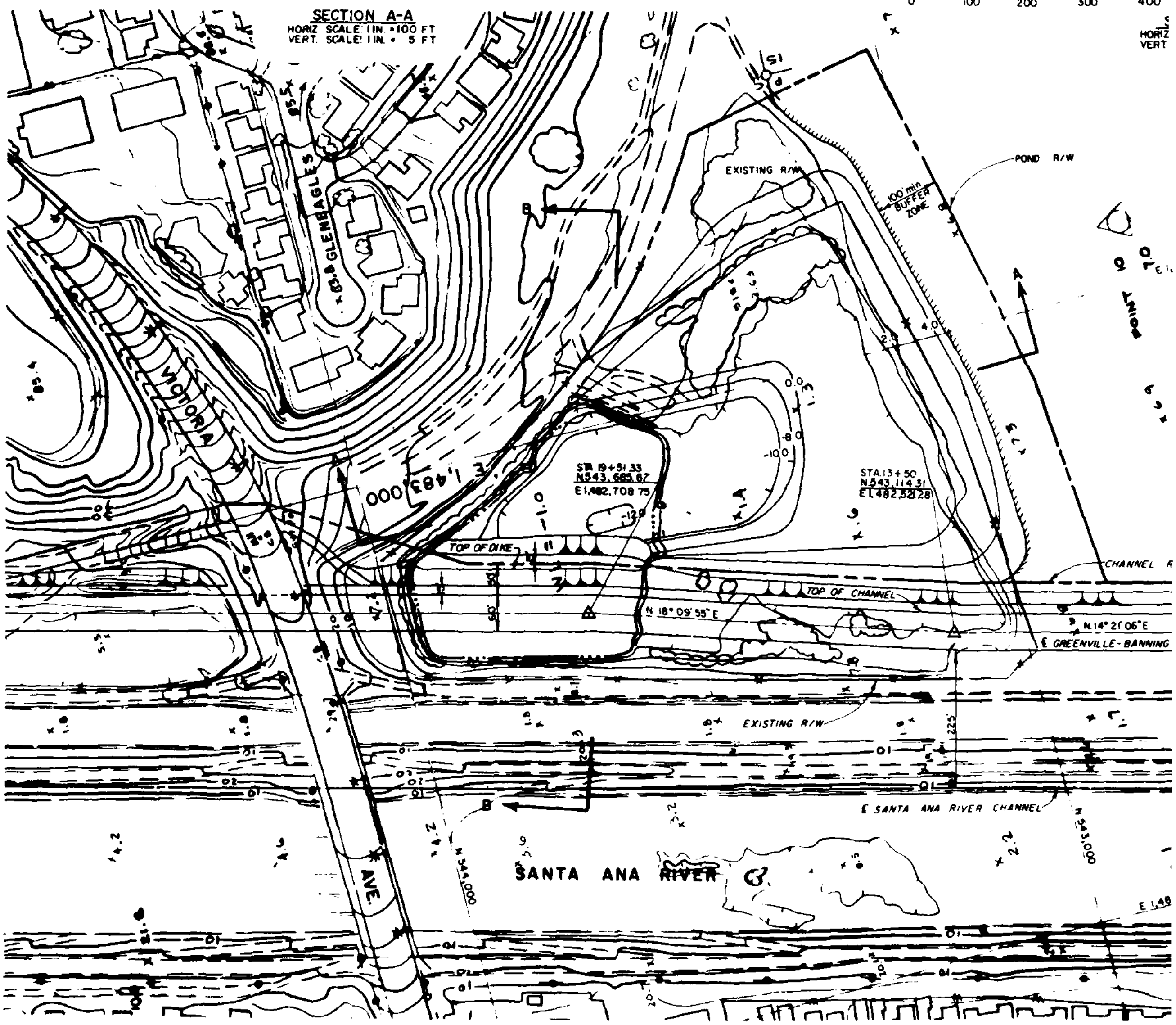
PLATE 76

2



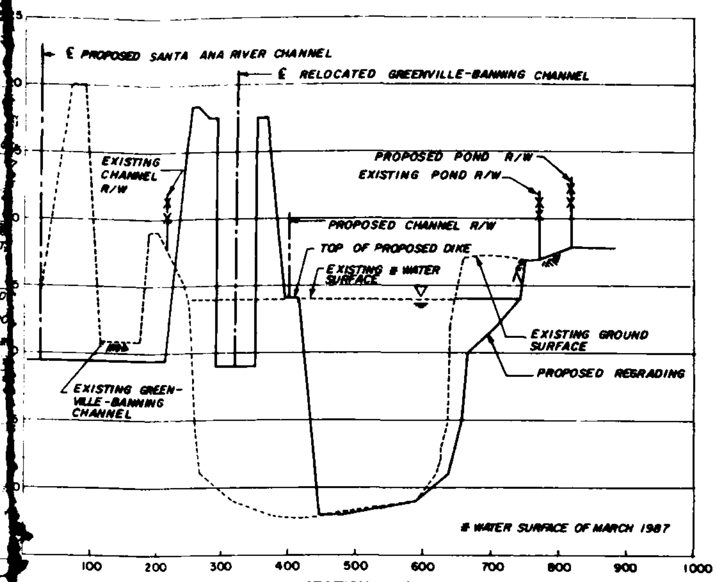
SECTION A-A
HORIZ SCALE: 1 IN. = 100 FT
VERT. SCALE: 1 IN. = 5 FT



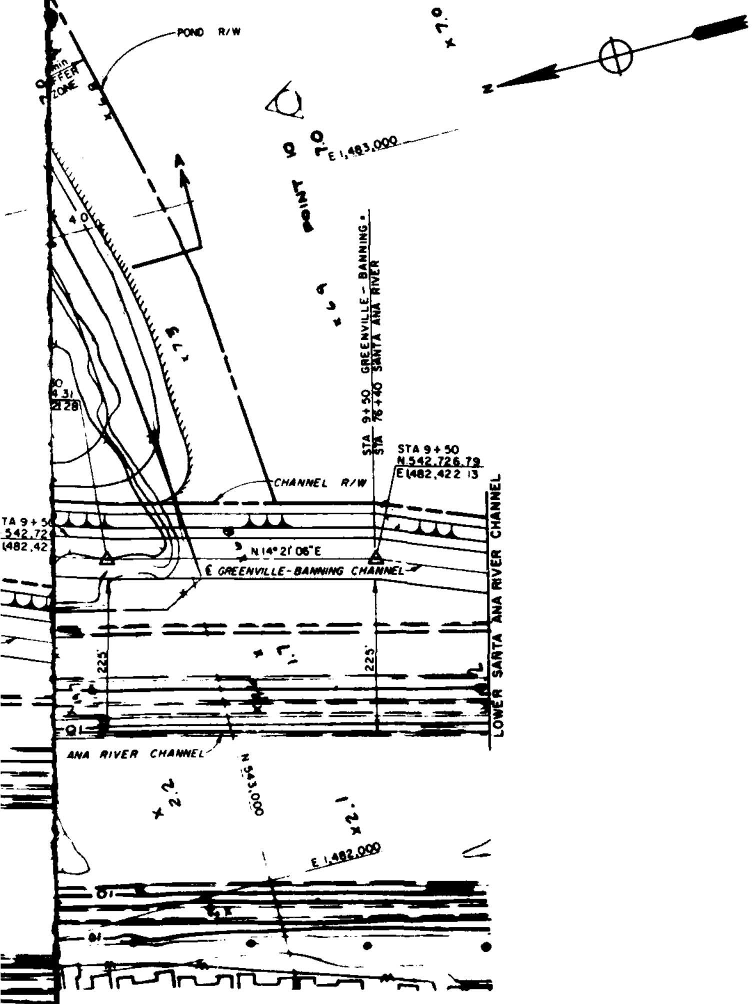


PLAN
SCALE 1 IN = 100 FT

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



SECTION B-B
HORIZ. SCALE: 1 IN. = 100 FT.
VERT. SCALE: 1 IN. = 5 FT.



NOTE: RIGHTS OF WAY
ORIGINAL AREA = 12.3 ACRES
PROPOSED AREA = 12.7 ACRES

SCALE: 1 IN. = 100 FT.
100 0 100 200 300

SCALE: 1 IN. = 5 FT.
5 0 5 10 15

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: DC
CHECKED BY:

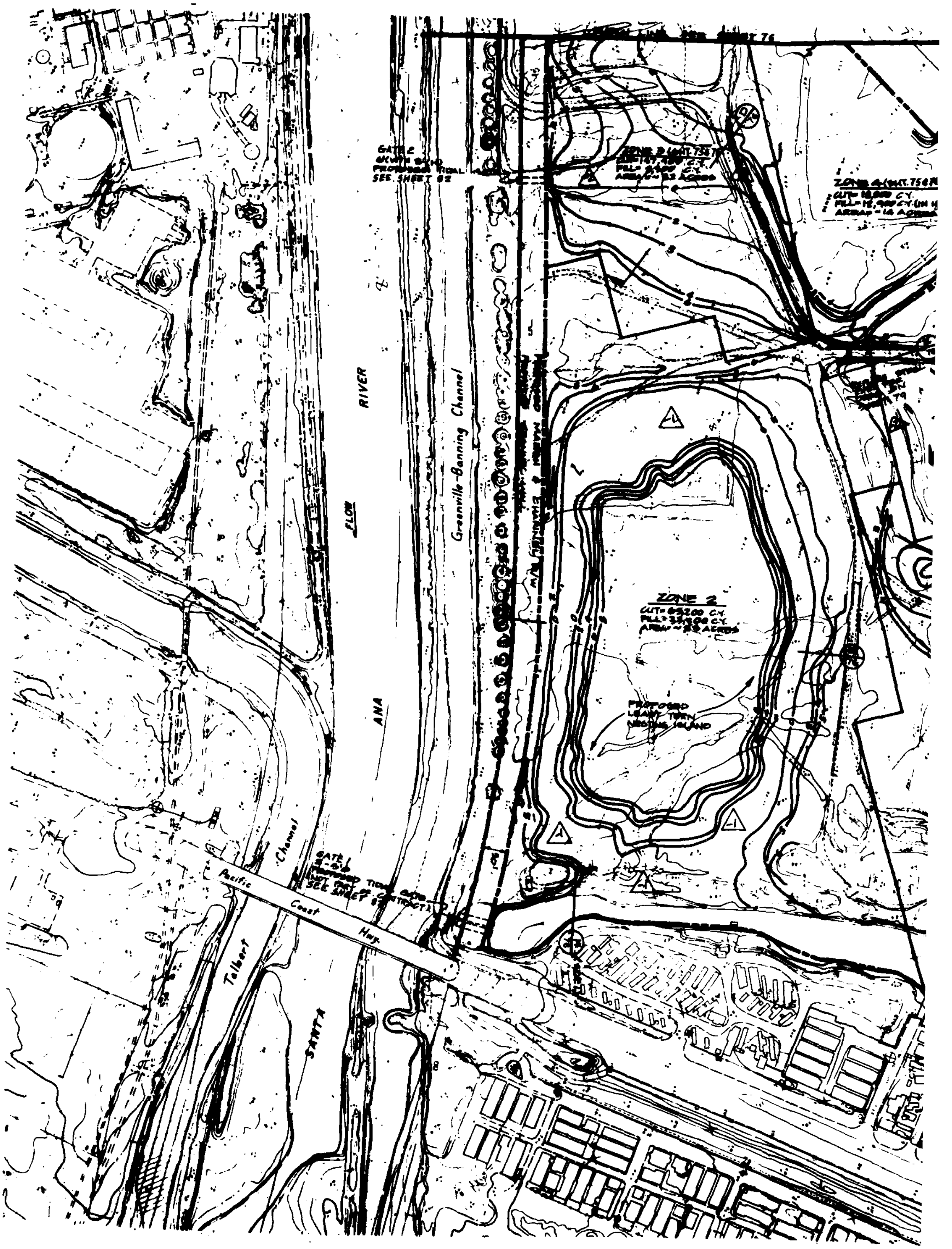
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER CHANNEL
VICTORIA POND
REGRADING

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 74 OF 105 SHEETS

PLATE 77

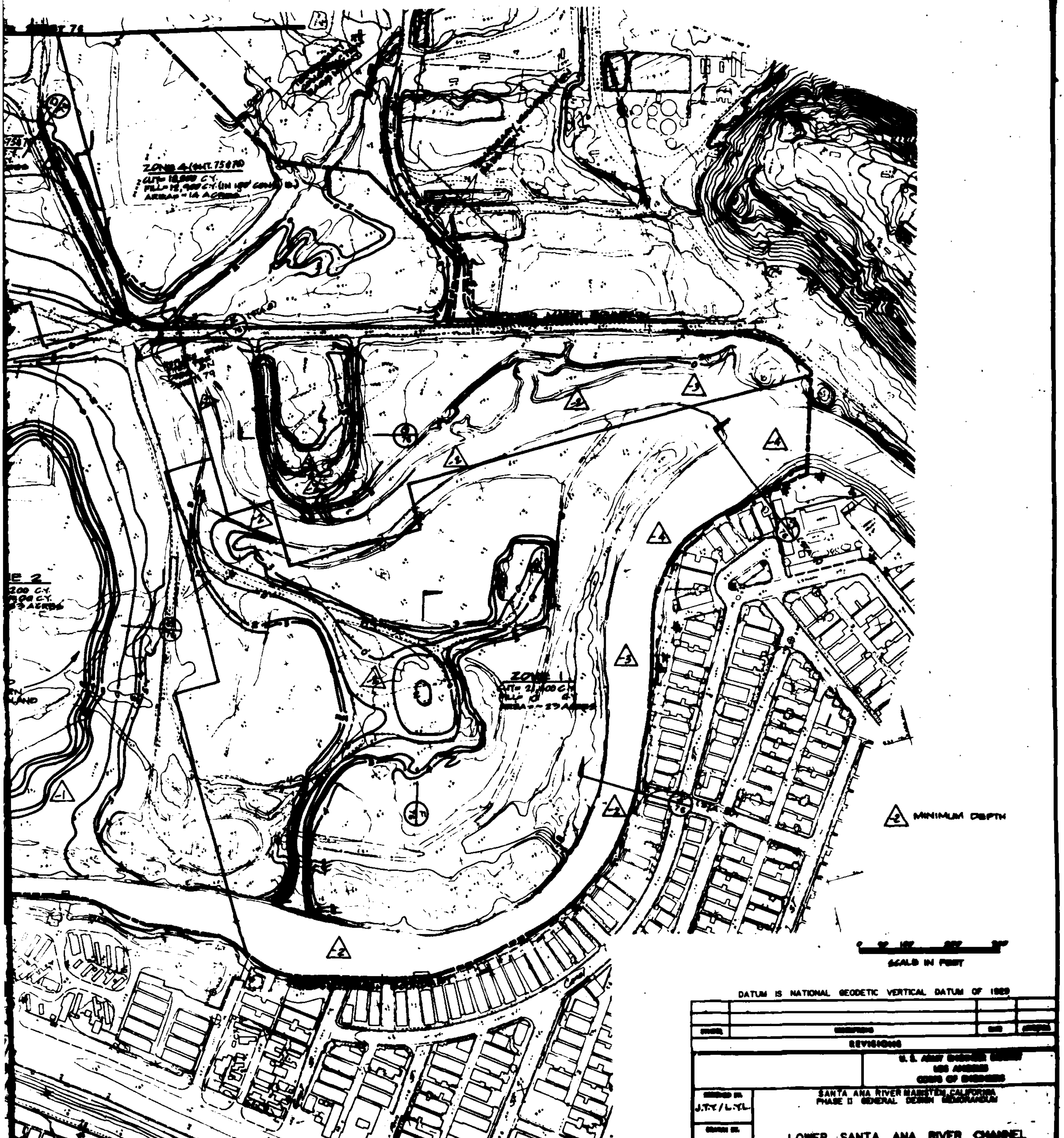
2

VALUE ENGINEERI



SAFETY PA

VALUE ENGINEERING PAYS



DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

J.T.Y./L.Y.L.

B.C.

L.Y.L.

LOWER SANTA ANA RIVER CHANNEL
MARSH RESTORATION

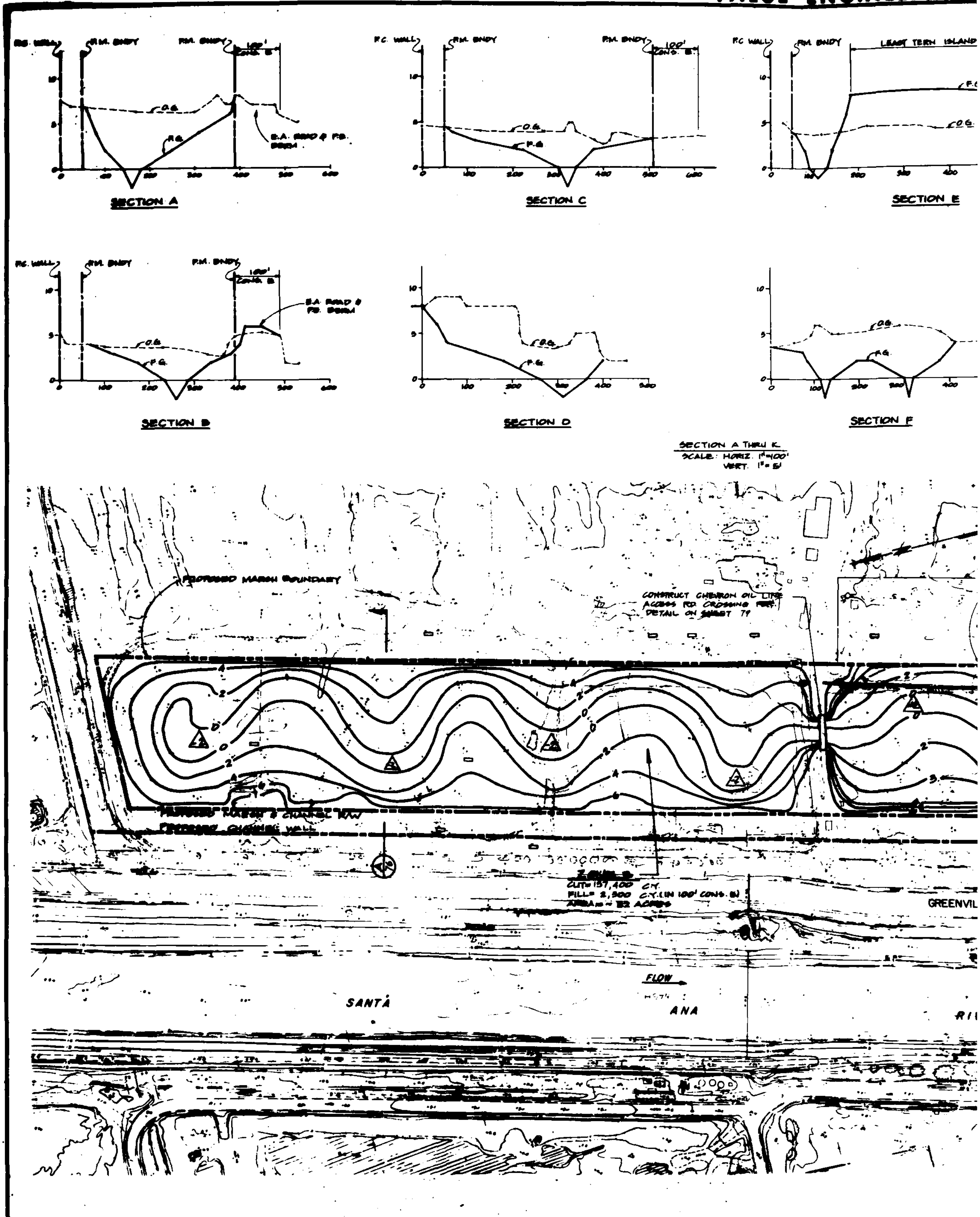
PROPOSED GRADING PLAN

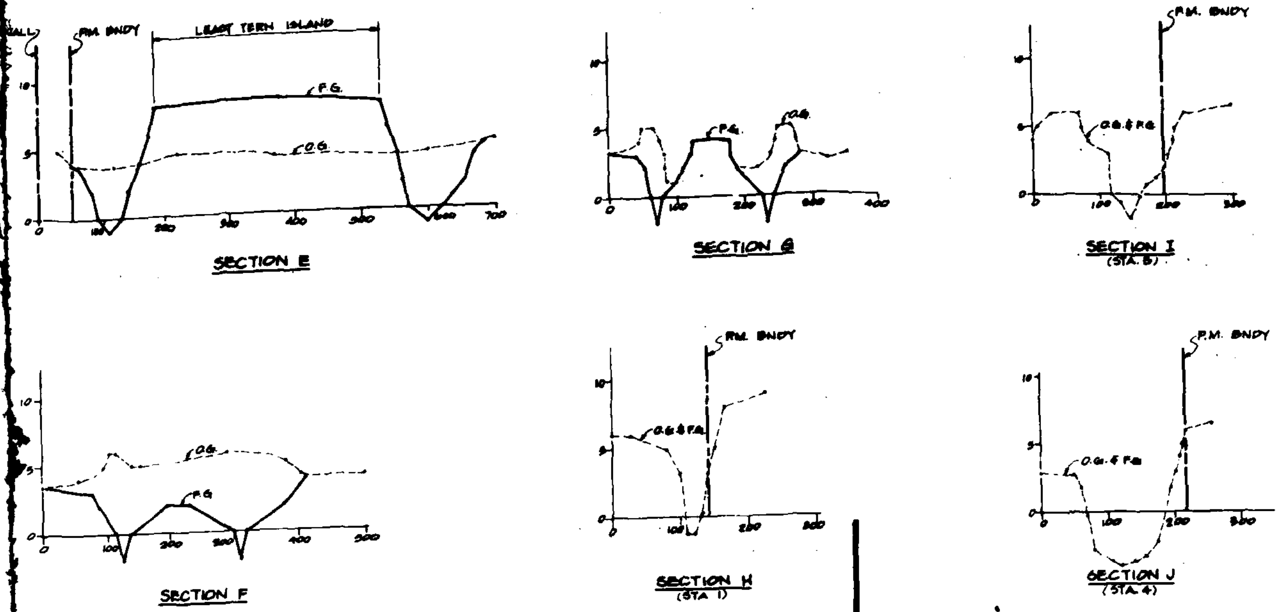
SHEET 75 OF 105 SHEETS

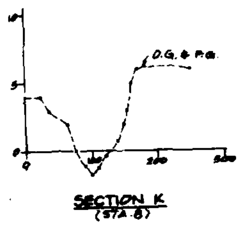
PLATE

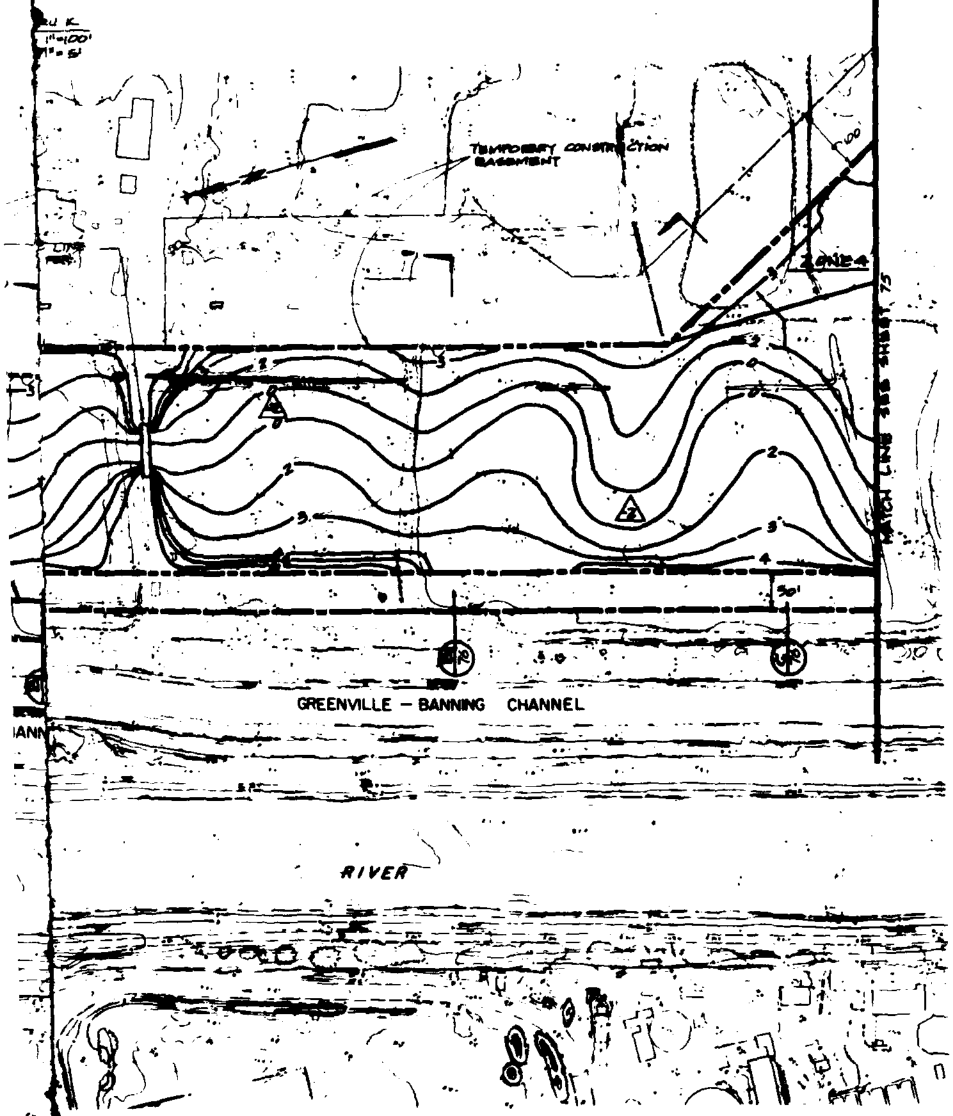
SAFETY PAYS

2


SECTION A
SECTION B
SECTION C
SECTION D
SECTION E
SECTION F
LEAST TERN ISLAND
SECTION A THRU K
SCALE: HORIZ. 1"=100'
VERT. 1"=5'
PROPOSED MARSH BOUNDARY
CONSTRUCT CHEVRON OIL LINE
ACCESS RD. CROSSING PER
DETAIL ON SHEET 79
PROPOSED CHANNEL WALL
CUT=157,400 C.Y.
FILL= 2,300 C.Y.
FLOW
SANTA
ANA
GREENVIL







ABBREVIATIONS

O.G.	ORIGINAL GRADE
F.G.	FINISHED GRADE
P.M. BNDY	PROPOSED MARSH BOUNDARY
P.C. WALL	PROPOSED CHANNEL WALL
P.E. BERM	PROPOSED EARTH BERM
E.A. ROAD	EXISTING ACCESS ROAD
S.R.C.	SURFACE RUNOFF CONTROL
CONS. E	CONSTRUCTION EASEMENT
R.C. HW	REINFORCED CONCRETE HEADWALL
T.W.	TOP OF WALL
B.W.	BOTTOM OF WALL
ST GR	STRAIGHT GRADE
H.P.	HIGH POINT
F.M.	FORCED MAIN
S	SEWER LINE
M.H	MANHOLE
△2	MINIMUM DEPTH

TOTAL (ZONE 1 THRU 4)

CUT = 166,800 C.Y.
FILL = 69,800 C.Y. (15,200 C.Y. FOR P.E. BERM IN CONS. E.)
AREA = ~42 ACRES

0 50 100 200 300
SCALE IN FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

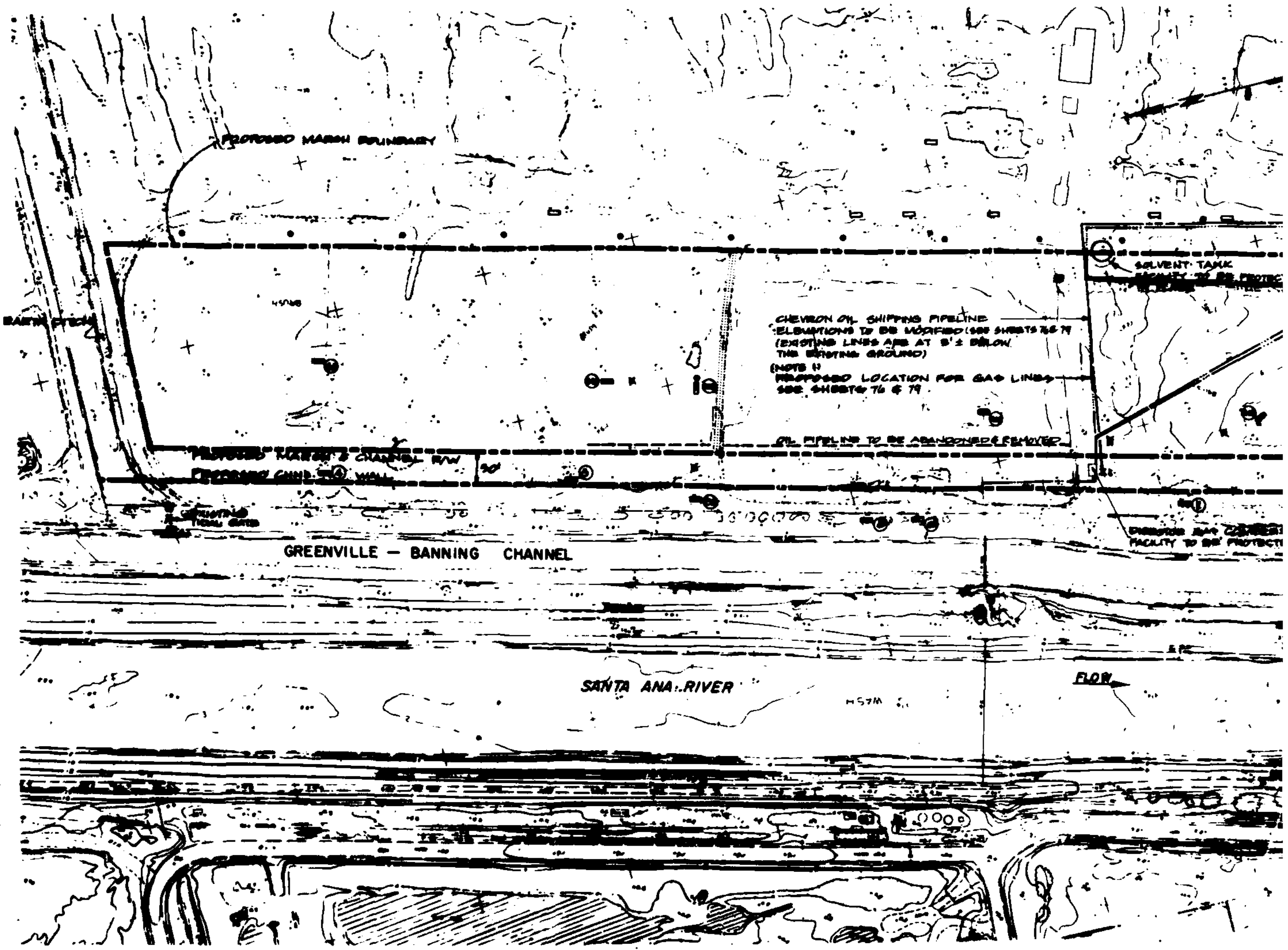
DESIGNED BY: J.T.Y./L.Y.L.
DRAWN BY: B.C.
CHECKED BY: L.Y.L.

LOWER SANTA ANA RIVER CHANNEL MARSH RESTORATION

PROPOSED GRADING PLAN

SHEET 78 OF 108 SHEETS

PLATE 78

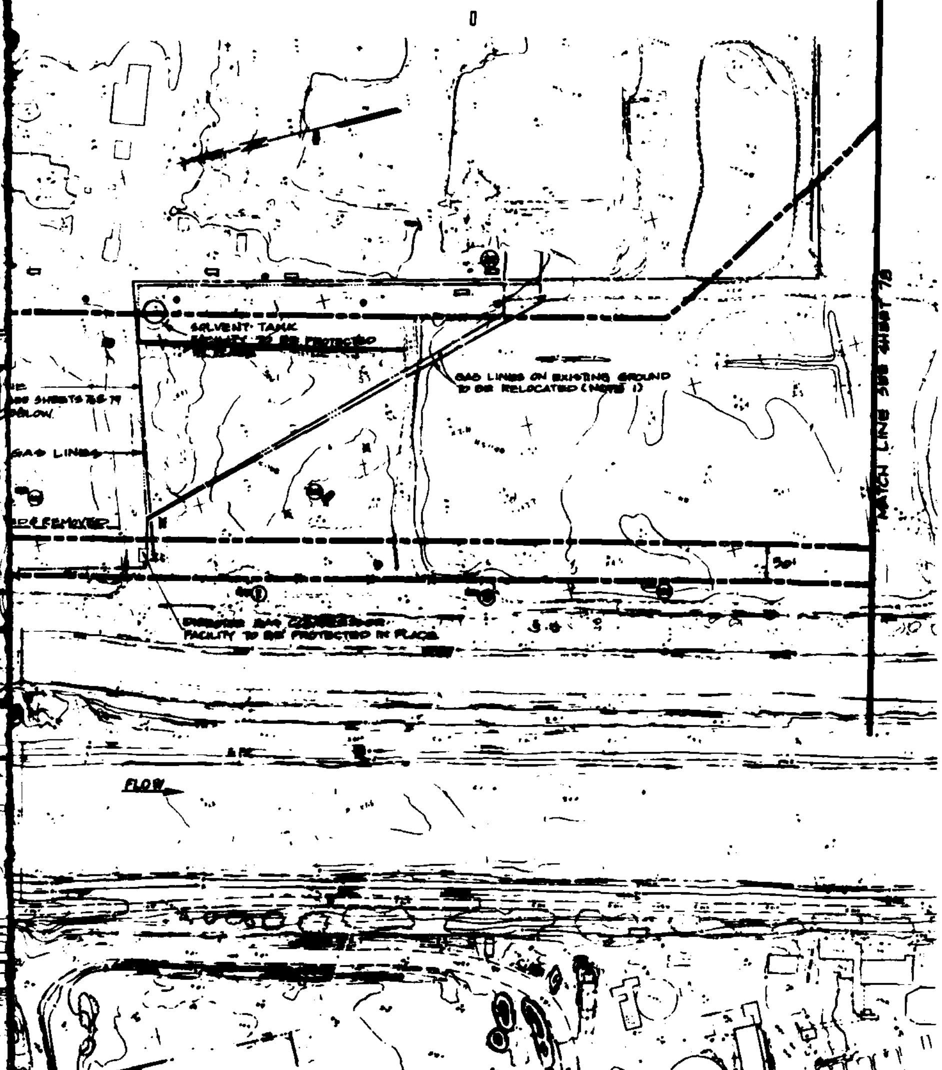

SOLVENT TANK
CHEVRON OIL SHIPPING PIPELINE
ELEVATIONS TO BE MODIFIED (SEE SHEETS 76 & 79
(EXISTING LINES ARE AT 5'± BELOW
THE EXISTING GROUND)
(NOTE 1)
PROPOSED LOCATION FOR GAS LINES
SEE SHEETS 76 & 79.
OIL PIPELINE TO BE ABANDONED & REMOVED
FACILITY TO BE PROTECTED
GREENVILLE — BANNING CHANNEL
SANTA ANA RIVER
FLOW

VALUE ENGINEERING PAYS

GENERAL NOTES

1. CONTRACTOR TO VERIFY THE ELEVATION OF CHEVRON OIL LINE PRIOR TO EXCAVATION.
2. CONTRACTOR TO CONTACT SOUTHERN CALIFORNIA EDISON COMPANY FOR POWER POLE REMOVAL.
3. CONTRACTOR TO VERIFY THE LOCATION AND ELEVATION OF THE CITY OF NEWPORT BEACH OIL LINE PRIOR TO EXCAVATION.
4. CONTRACTOR TO OBTAIN APPLICABLE REGULATIONS AND PERMITS PRIOR TO ABANDON AND/OR RELOCATION OF OIL WELLS.
5. CONTRACTOR TO MODIFY THE OIL WELLS FOR PROPOSED FINISHED ELEVATIONS ON SHEETS 75 AND 76
6. CONTRACTOR TO CONTACT WEST NEWPORT OIL COMPANY FOR OIL WELL RELOCATION.
7. CONTACT PERSONS:

UTILITY	TELEPHONE	PERSON
WEST NEWPORT OIL COMPANY	(714) 650-4000	LEONARD W. ANDERSON
WEST NEWPORT OIL COMPANY FIELD OFFICE	(714) 631-1100	JAY E. STAIR
ORANGE COUNTY SANITATION DISTRICT	(714) 962-2411 (714) 540-2910	RUSS WOLD
SOUTHERN CALIFORNIA EDISON	(714) 895-0209	E. JOHN MCMANN
CHEVRON OIL PIPELINE	(213) 694-7669 (213) 694-2616	JOE KENEALAS MARGO BART
CITY OF NEWPORT BEACH	(714) 644-3011	JOSEPH T. DEVLIN



LEGEND

- OIL WELL NUMBER, BANNING-6R
- ABANDONED OIL WELL
- OIL WELL TO BE ABANDONED AND REPLACED
- OIL WELL TO BE PROTECTED IN PLACE
- OIL WELL TO BE ABANDONED
- POWER POLE TO BE PROTECTED IN PLACE
- POWER POLE TO BE ABANDONED
- ACCESS ROAD TO BE ABANDONED
- ACCESS ROAD TO BE MAINTAINED
- FM FORCED MAIN
- S SEWER LINE
- MH MANHOLE

0 50 100 200 300

SCALE IN FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: J.T.Y./L.Y.L.

DRAWN BY: T.C.

CHECKED BY: L.Y.L.

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL MARSH RESTORATION

OIL WELL, UTILITY AND ACCESS RD

SUBMITTED BY: | DATE APPROVED: | DRAWING FILE NO.

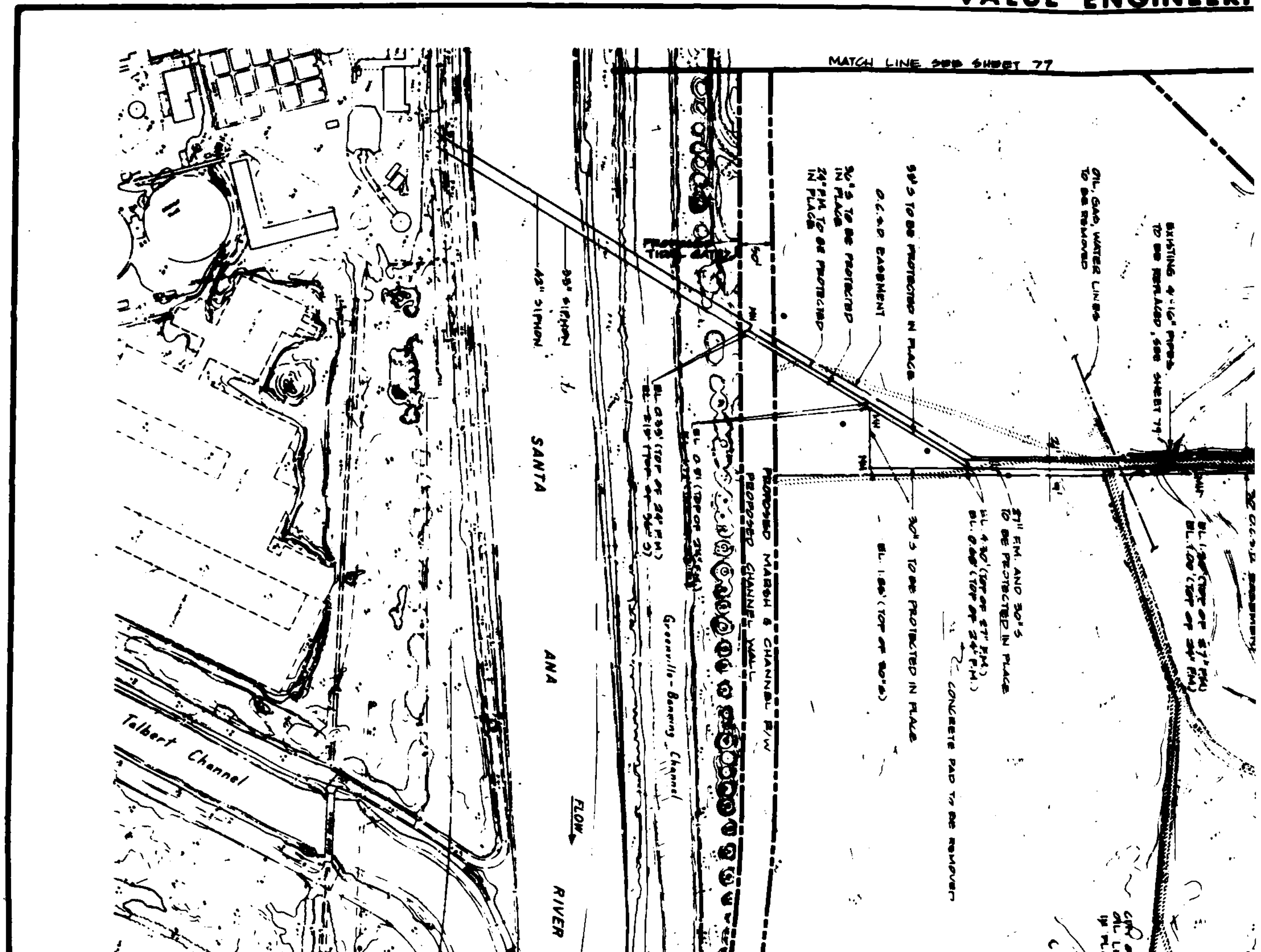
SHEET 77 OF 108 SHEETS

PLATE

SAFETY PAYS

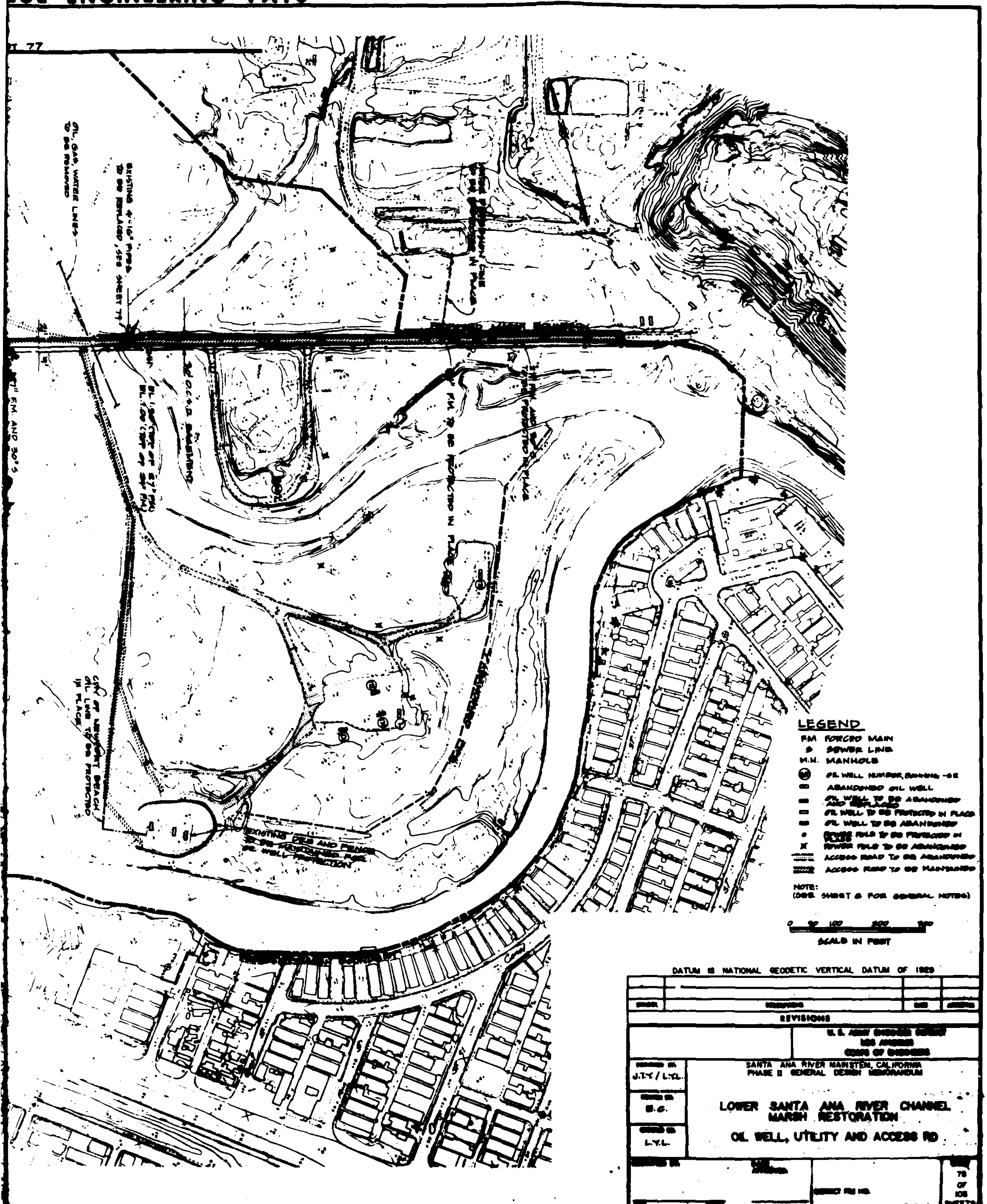
2

VALUE ENGINEERI



SAFETY PA

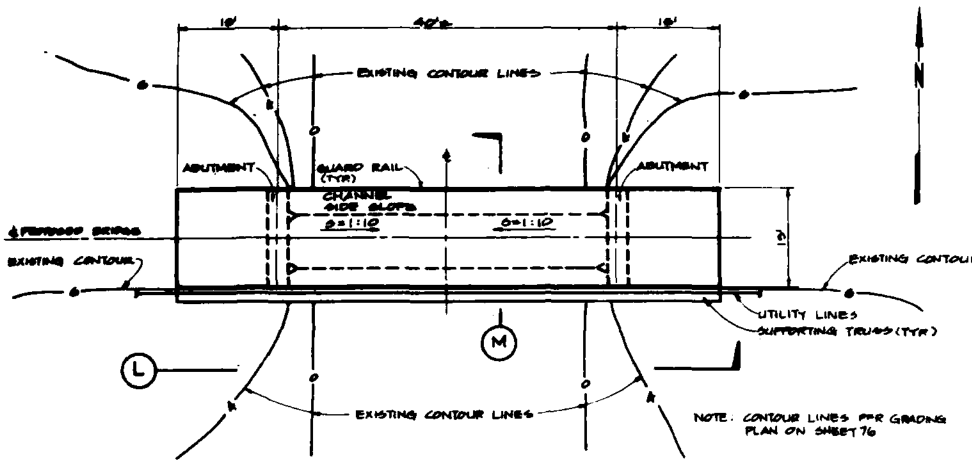
LUE ENGINEERING PAYS



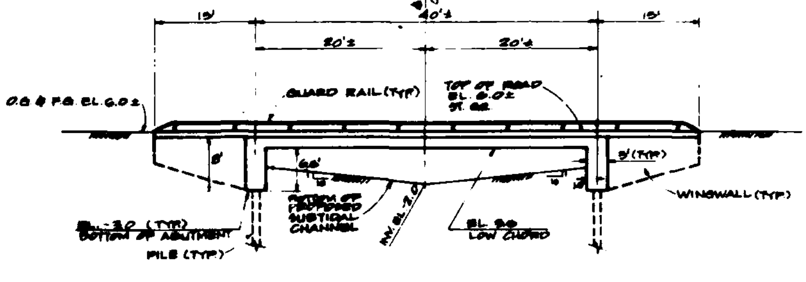
SAFETY PAYS

PLATE 81

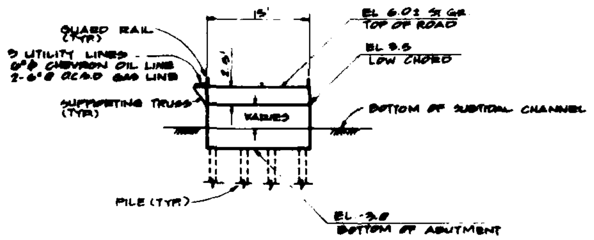
2



PLAN
NTS

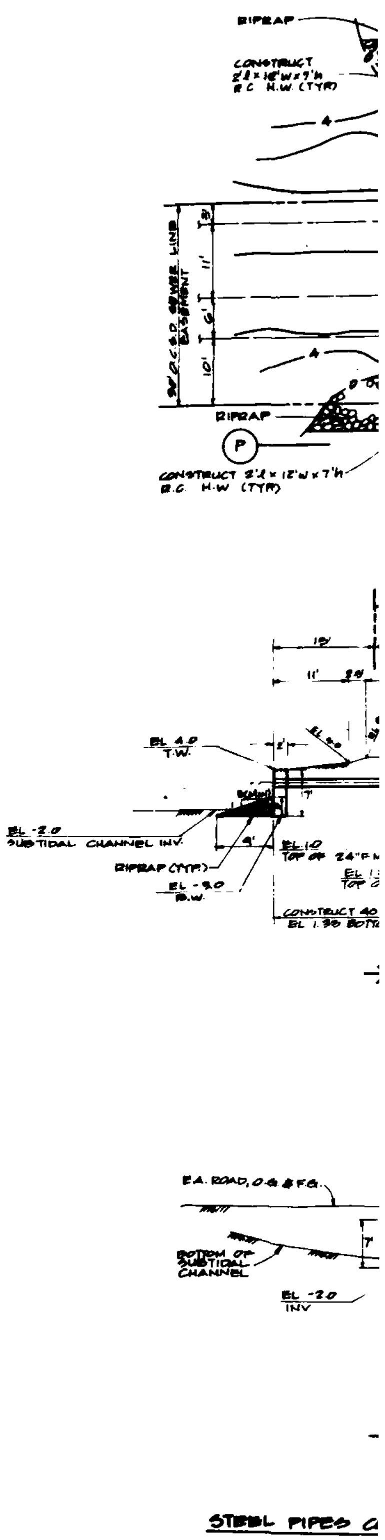


SECTION L
NTS



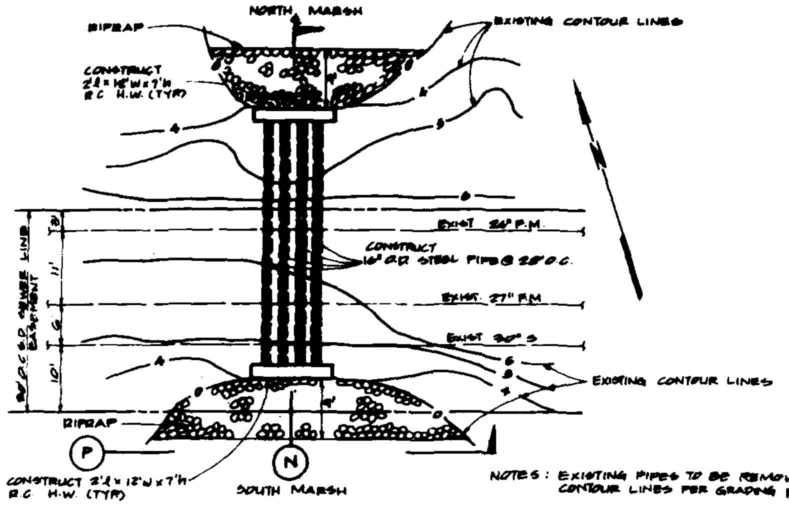
SECTION M
NTS

CHEVRON OIL LINE ACCESS RD CROSSING



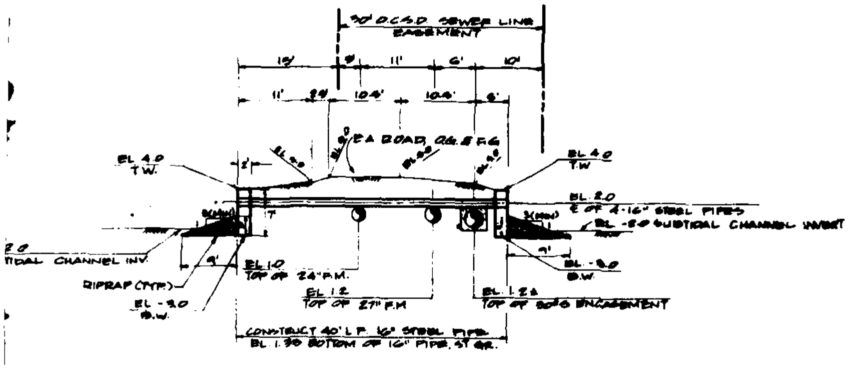
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

UE ENGINEERING PAYS

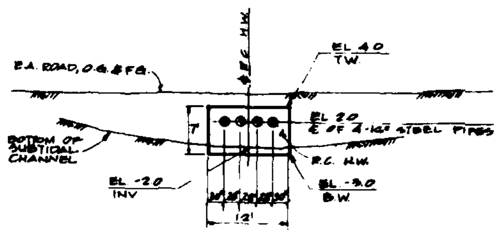


NOTES: EXISTING PIPES TO BE REMOVED.
CONTOUR LINES PER GRADING PLAN ON SHEET 75

PLAN
SCALE 1"=10'



SECTION N
SCALE 1"=10'



SECTION P
SCALE 1"=10'

STEEL PIPES CONNECTING NORTH & SOUTH MARSHES

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY: J.T.Y./L.Y.L.
DRAWN BY: B.C.
CHECKED BY: L.Y.L.

LOWER SANTA ANA RIVER CHANNEL MARSH RESTORATION

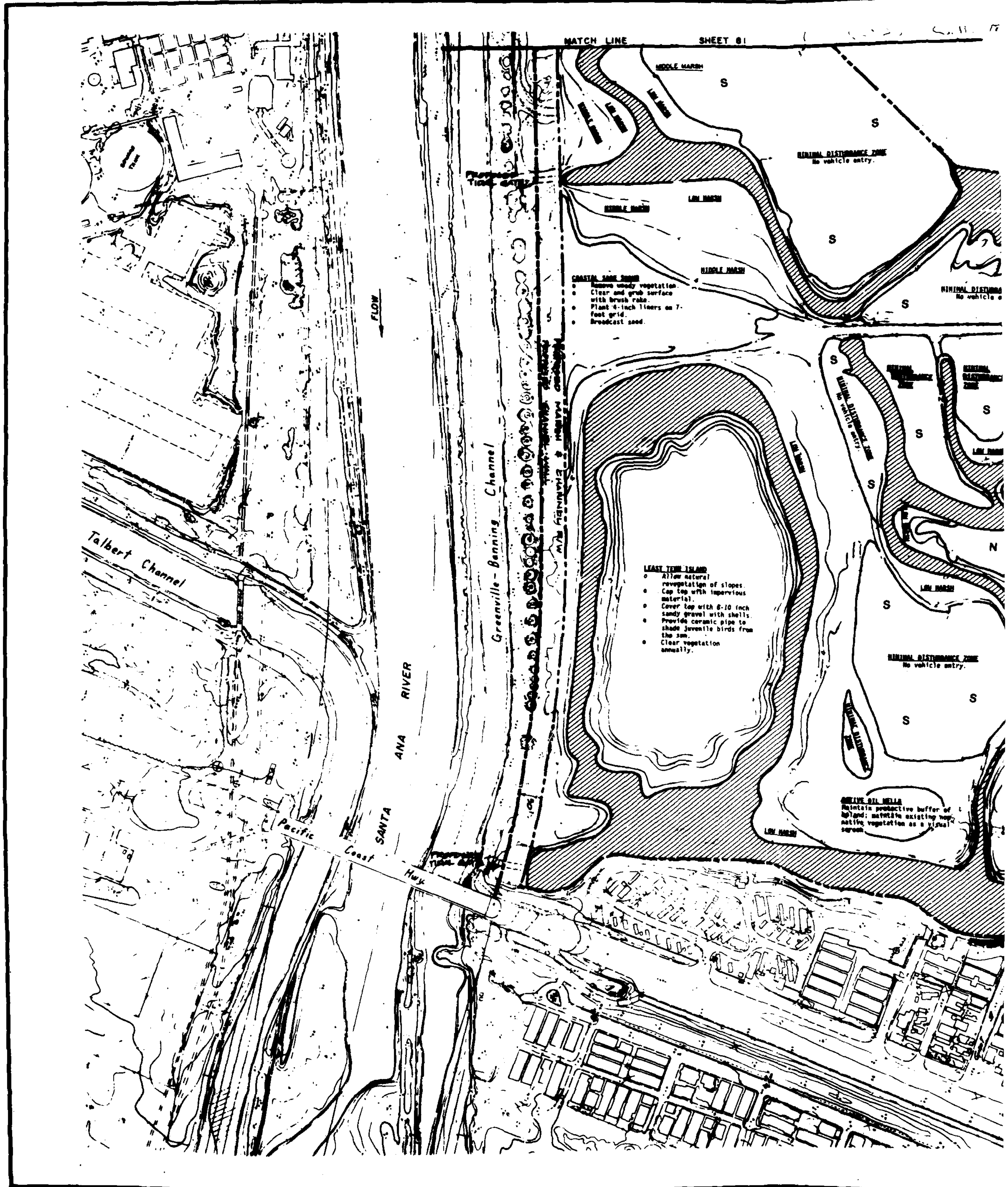
MISCELLANEOUS DETAILS

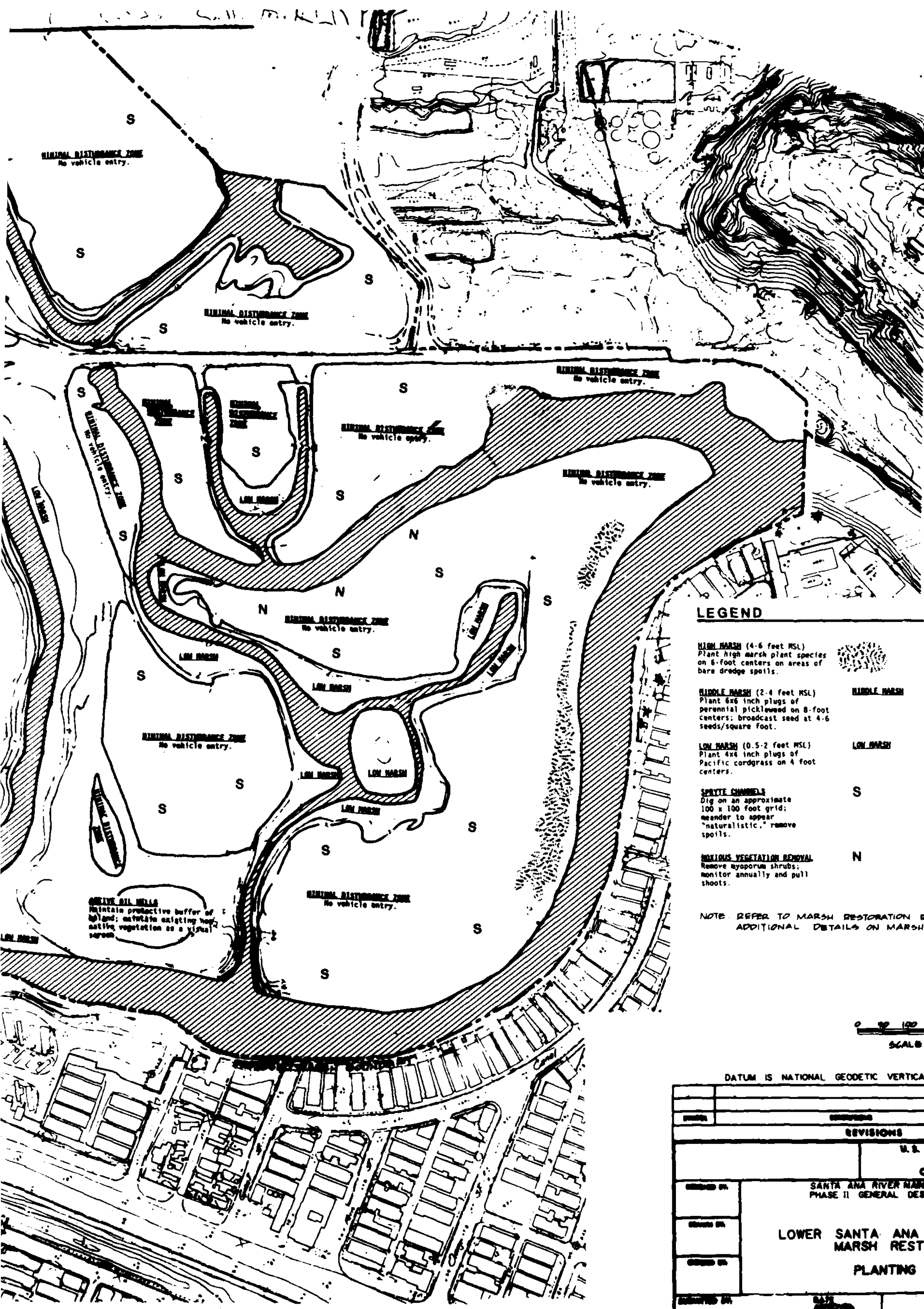
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 79 OF 105 SHEETS

PLATE 82

SAFETY PAYS

2


MATCH LINE SHEET 61
MIDDLE MARSH
LOW MARSH
MINIMAL DISTURBANCE ZONE
No vehicle entry.
COASTAL SAGE SCRUB
• Remove woody vegetation.
• Clear and grub surface with brush rake.
• Plant 4-inch liners on 7-foot grid.
• Broadcast seed.
FLOW
Greenville-Banning Channel
LEAST TERN ISLAND
• Allow natural revegetation of slopes.
• Cap top with impervious material.
• Cover top with 6-10 inch sandy gravel with shells.
• Provide ceramic pipe to shade juvenile birds from the sun.
• Clear vegetation annually.
Talbert Channel
SANTA ANA RIVER
Pacific Coast Hwy
ACTIVE OIL WELLS
Maintain protective buffer of upland; maintain existing non-native vegetation as a visual screen.
S
N



LEGEND

HIGH MARSH (4-6 feet MSL) Plant high marsh plant species on 6-foot centers on areas of bare dredge spoils.	
MIDDLE MARSH (2-4 feet MSL) Plant 6x6 inch plugs of perennial pickleweed on 8-foot centers; broadcast seed at 4-6 seeds/square foot.	MIDDLE MARSH
LOW MARSH (0.5-2 feet MSL) Plant 4x4 inch plugs of Pacific cordgrass on 4 foot centers.	LOW MARSH
SPRYTE CHANNELS Dig on an approximate 100 x 100 foot grid; meander to appear "naturalistic," remove spoils.	S
NOXIOUS VEGETATION REMOVAL Remove myoporum shrubs; monitor annually and pull shoots.	N

NOTE: REFER TO MARSH RESTORATION REPORT FOR ADDITIONAL DETAILS ON MARSH PLANTING

0 50 100 200 300
SCALE IN FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
MARSH RESTORATION

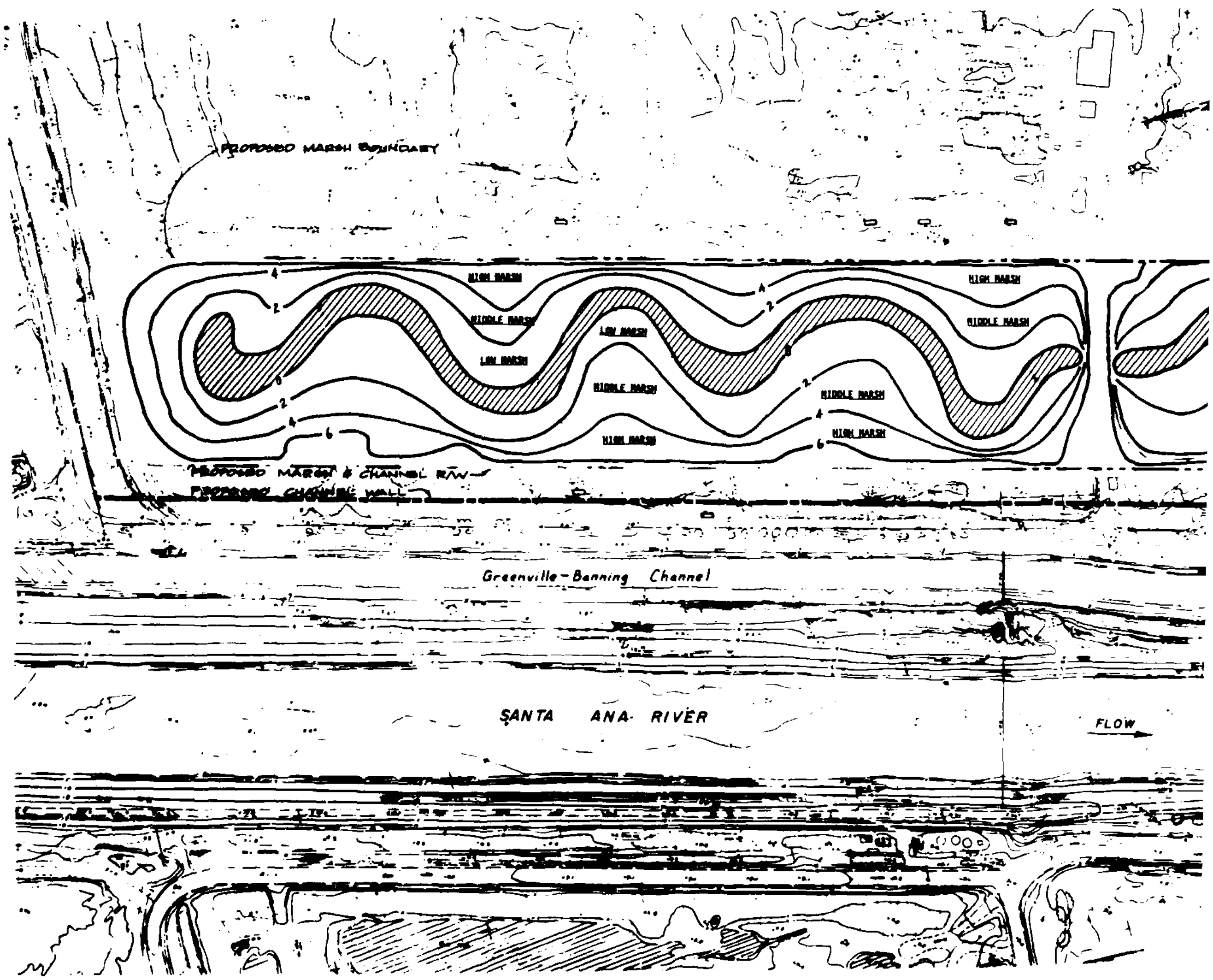
PLANTING PLAN

SHEET 80 OF 105 SHEETS

PLATE 83

12

ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING



Legend

LOW MARSH (0.5-2 feet MSL)
Plant 4x4 inch plugs of Pacific cordgrass on 4-foot centers.

MIDDLE MARSH (2-4 feet MSL)
Plant 6x6 inch plugs of perennial pickleweed on 8-foot centers; broadcast seed at 4-6 seeds/square foot.

HIGH MARSH (4-6 feet MSL)
Plant high marsh plant species on 6-foot centers.

0 50 100 200 300
SCALE IN FEET

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
MARSH RESTORATION

PLANTING PLAN

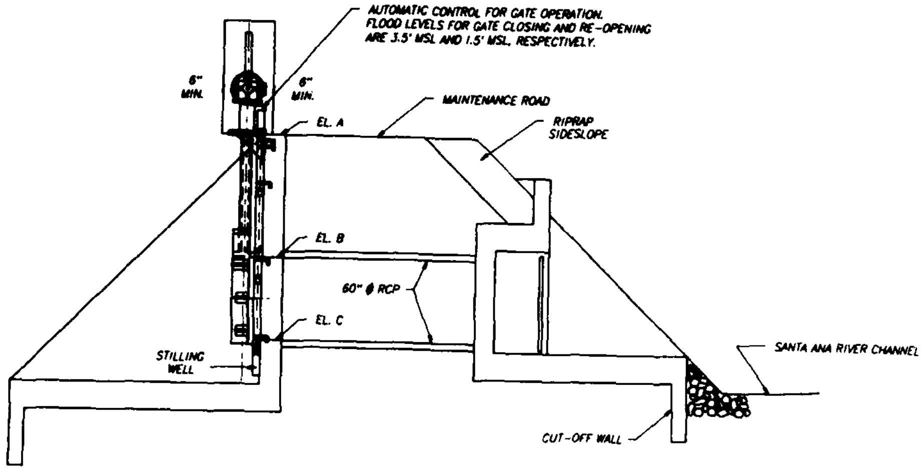
SHEET 81 OF 105 SHEETS

PLATE 84

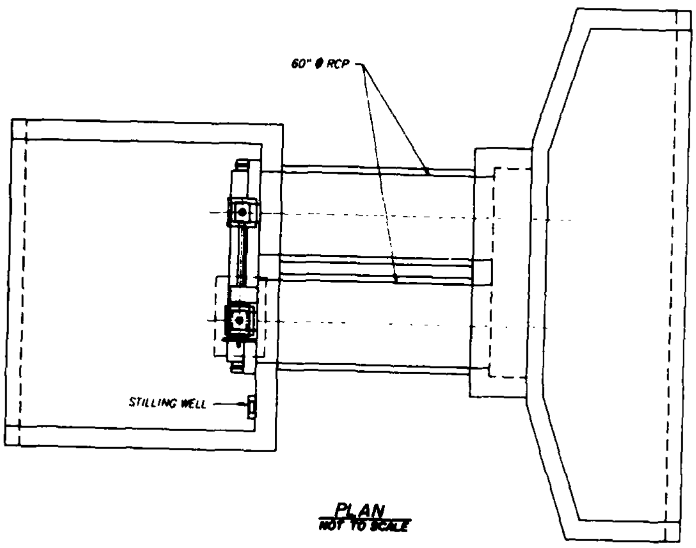
2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

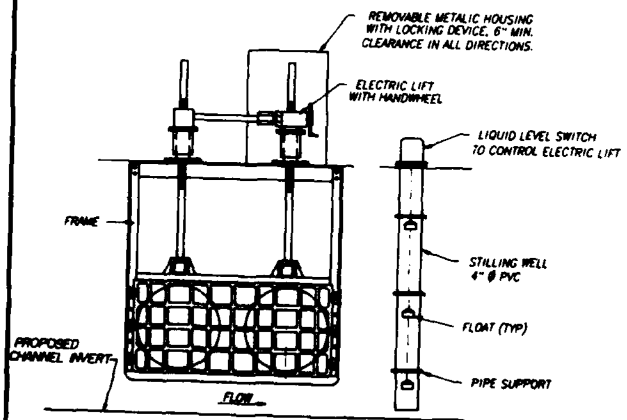
VALUE ENGINEERIN



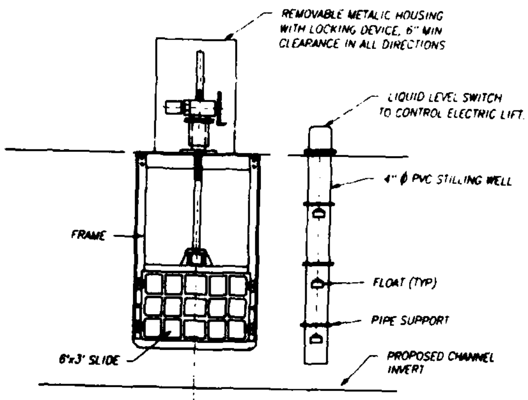
SIDE VIEW OF GATES
NOT TO SCALE



PLAN
NOT TO SCALE



FRONT VIEW OF GATE NO. 1
NOT TO SCALE

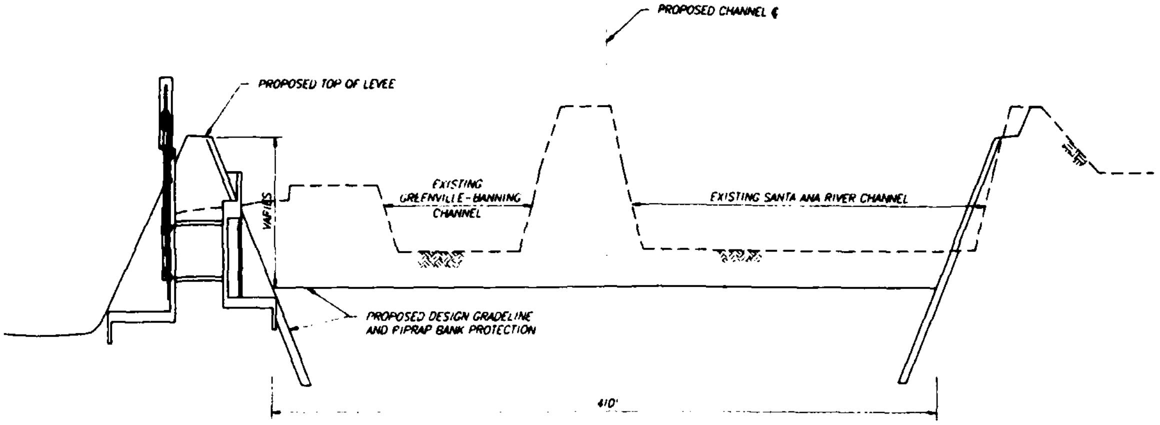


FRONT VIEW OF GATE NO. 2
NOT TO SCALE

SAFETY PA

VALUE ENGINEERING PAYS

ANNEL



TYPICAL SECTION
NOT TO SCALE

	TIDAL GATES	
	NO. 1	NO. 2
STATION	10+50	29+00
GATE SIZE	60" D	6'x3'
NO. OF GATE(S)	1	1
MATERIAL	AUSTENITIC GRAY IRON (NI-RESIST)	
ELEV. A*(MSL)	12.3'	13.9'
ELEV. B (MSL)	1.0'	2.0'
ELEV. C (MSL)	-4.0'	-1.0'

* APPROXIMATE TOP OF LEVEE

METALLIC HOUSING
DEVICE, 6" MIN
ALL DIRECTIONS

LIQUID LEVEL SWITCH
TO CONTROL ELECTRIC LIFT

4" ϕ PVC STILLING WELL

FLOAT (TYP)

PIPE SUPPORT

PROPOSED CHANNEL INVERT

SYMBOL | DESCRIPTIONS | DATE | APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL

TIDE GATES

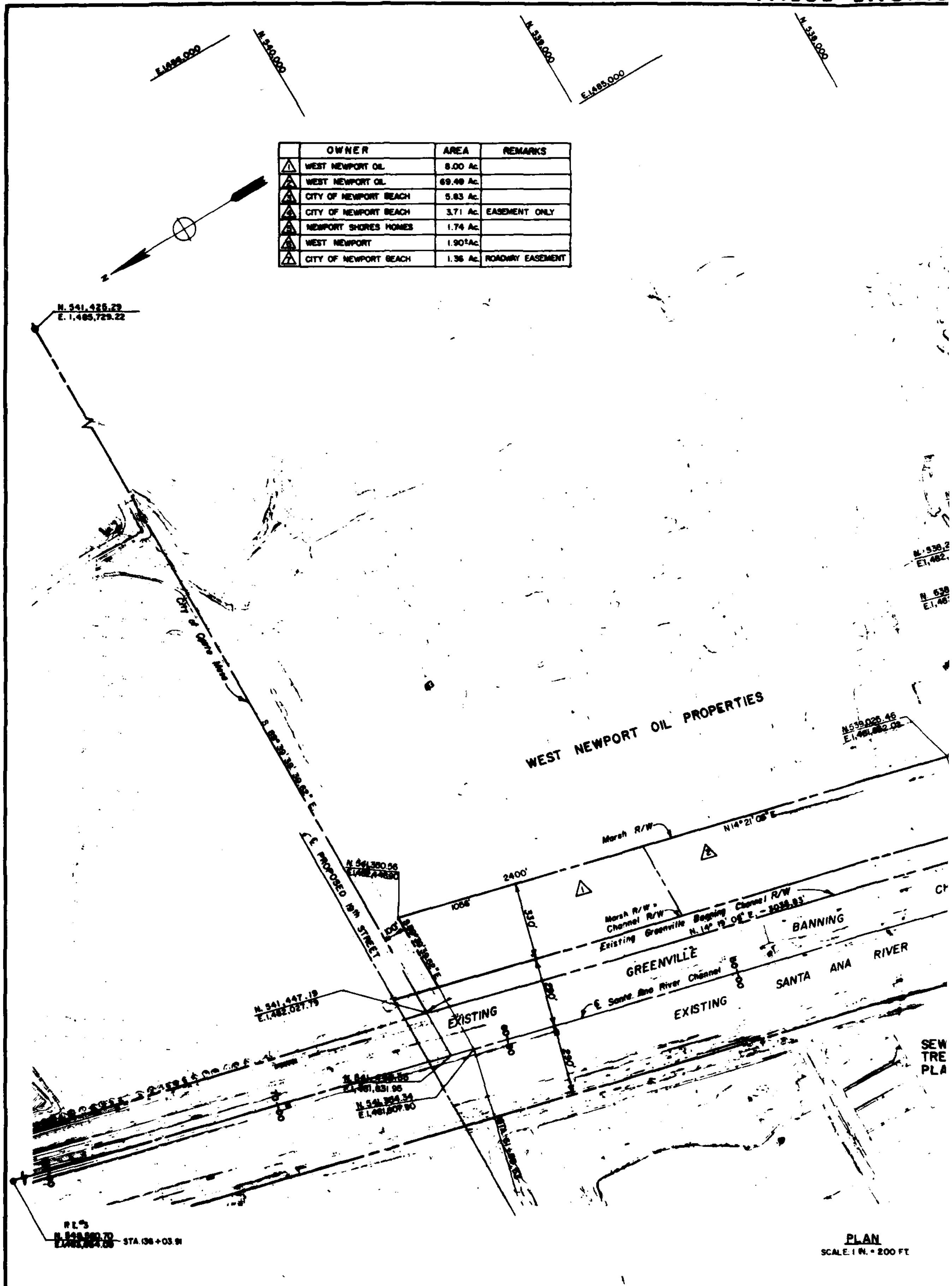
SUBMITTED BY: | DATE APPROVED: | DISTRICT FILE NO. | SHEET 82 OF 105 SHEETS

PLATE 86

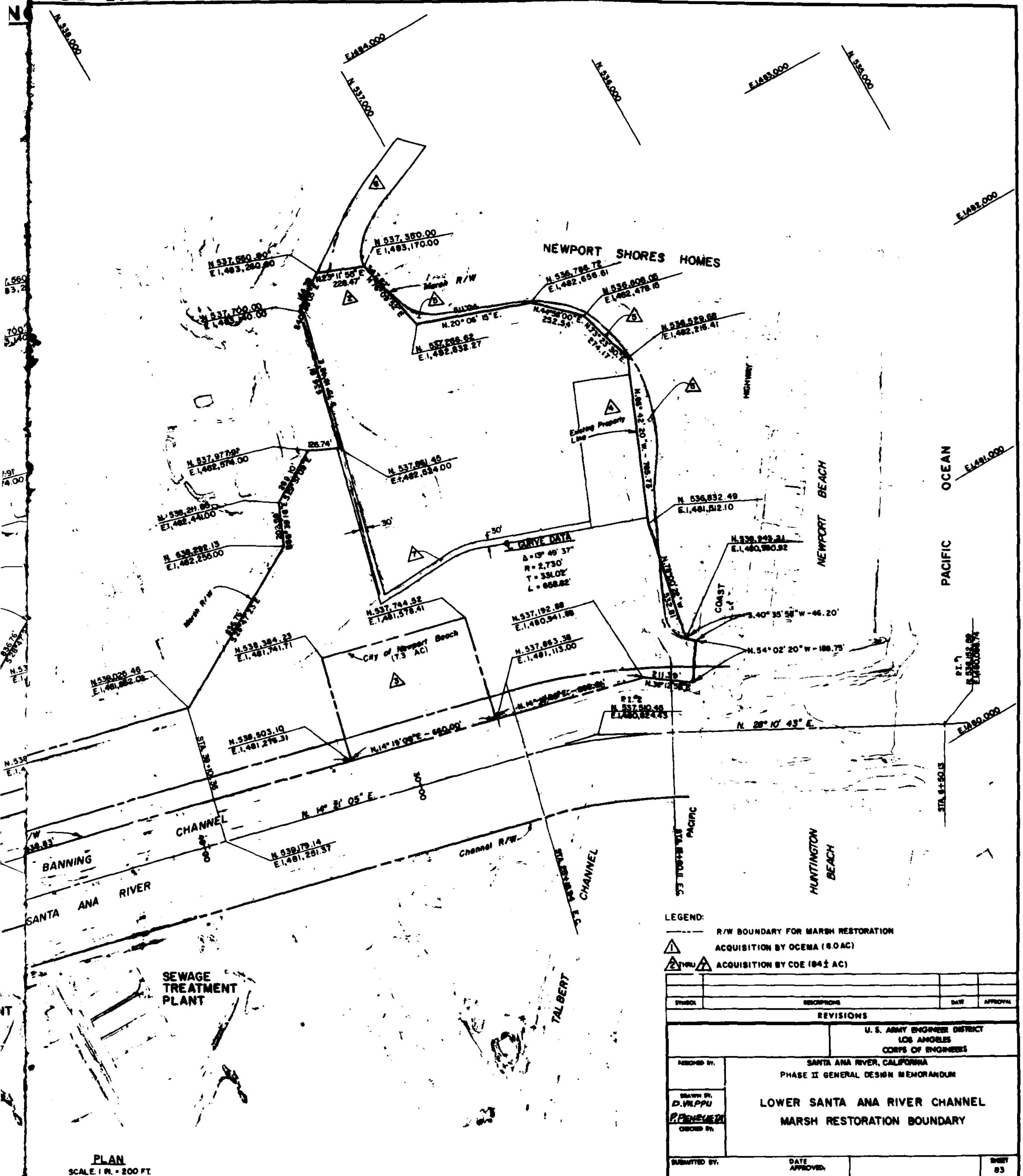
SAFETY PAYS

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

	OWNER	AREA	REMARKS
1	WEST NEWPORT OIL	8.00 Ac.	
2	WEST NEWPORT OIL	69.40 Ac.	
3	CITY OF NEWPORT BEACH	5.83 Ac.	
4	CITY OF NEWPORT BEACH	3.71 Ac.	EASEMENT ONLY
5	NEWPORT SHORES HOMES	1.74 Ac.	
6	WEST NEWPORT	1.90±Ac.	
7	CITY OF NEWPORT BEACH	1.36 Ac.	ROADWAY EASEMENT



PLAN
SCALE: 1 IN. = 200 FT.



PLAN
SCALE: 1 IN. = 200 FT.

LEGEND:

- R/W BOUNDARY FOR MARSH RESTORATION
- △1 ACQUISITION BY OCEMA (8.0 AC)
- △2 thru △7 ACQUISITION BY COE (94± AC)

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

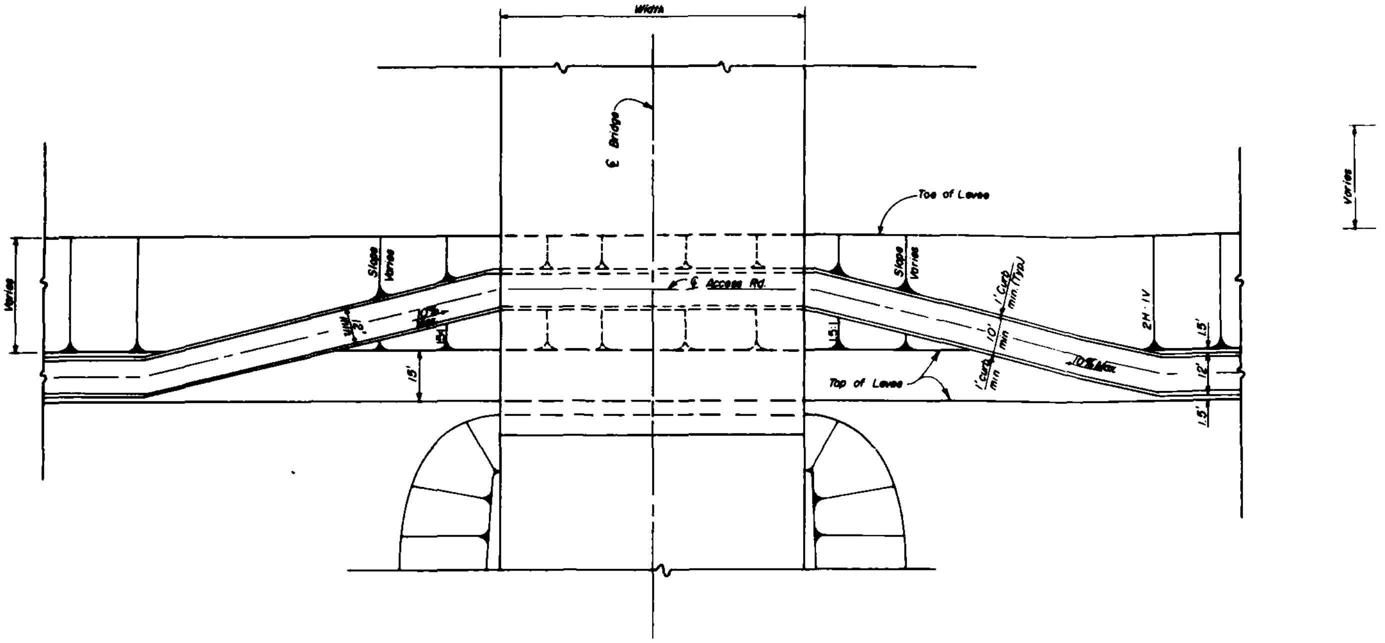
SANTA ANA RIVER, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
MARSH RESTORATION BOUNDARY

DESIGNED BY:
DRAWN BY: D.VILPPU
P.PENEUETA
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 83 OF 105

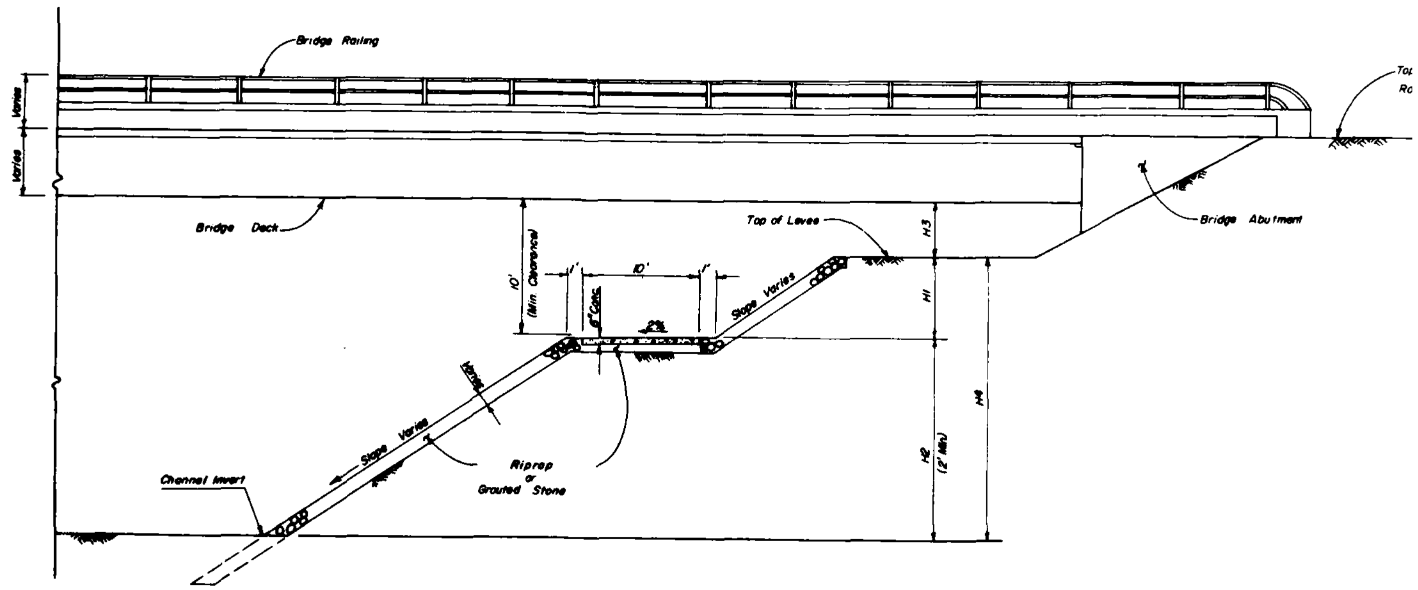
PLATE 86

2

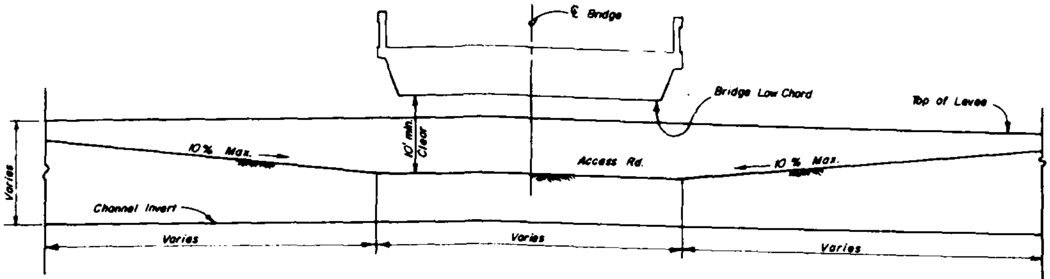


PLAN
NOT TO SCALE

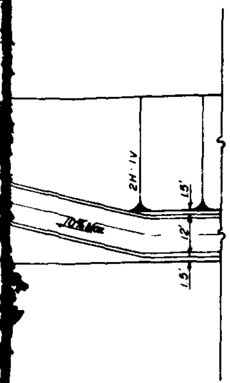
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

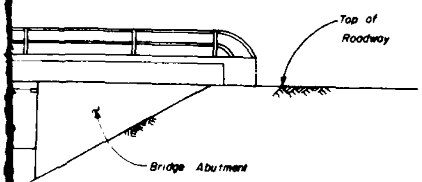


ELEVATION
NOT TO SCALE



PROFILE
NOT TO SCALE





SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY:
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

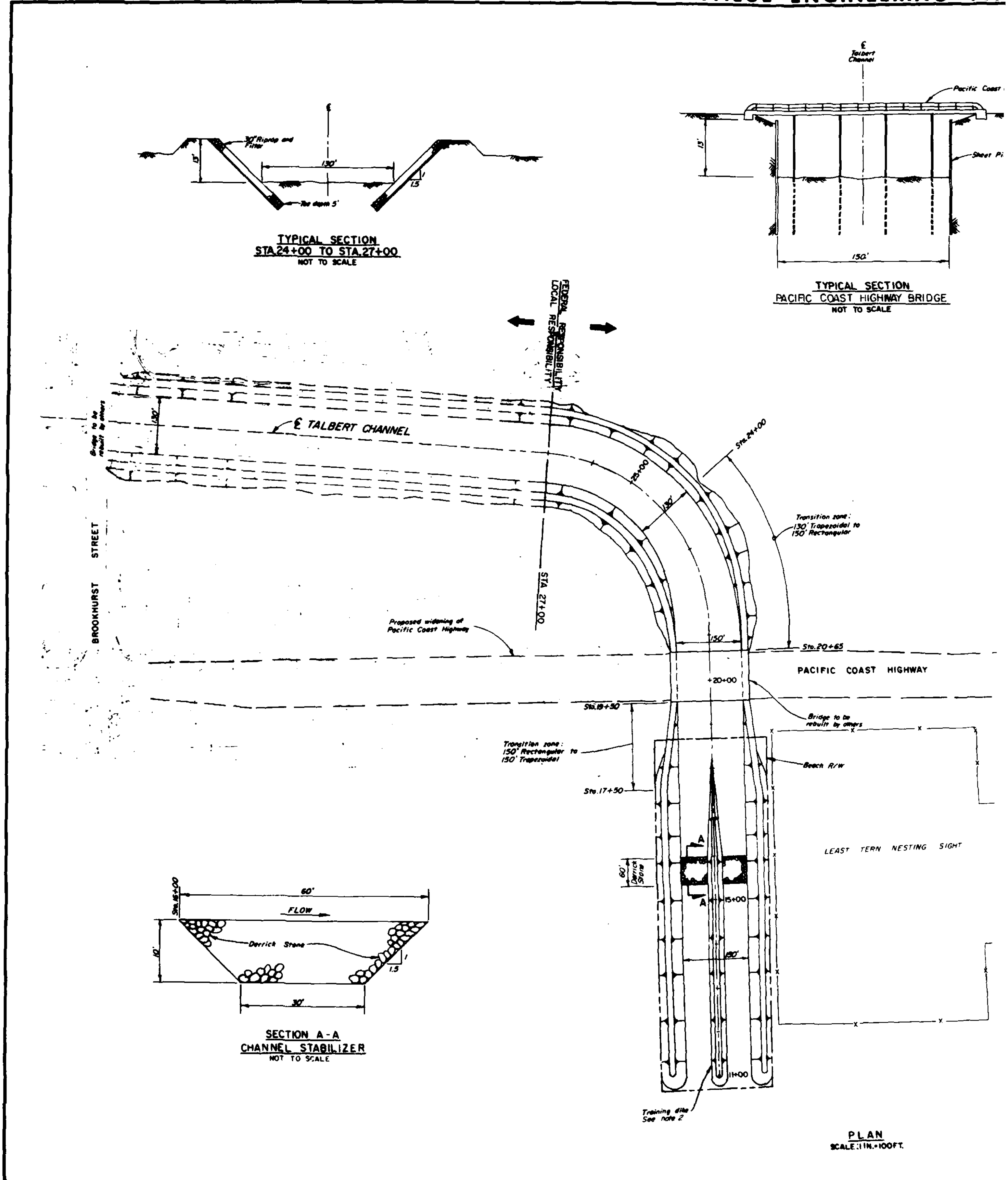
LOWER SANTA ANA RIVER CHANNEL
TYPICAL ACCESS ROAD

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 84 OF 105 SHEETS
PLATE 87

1

2

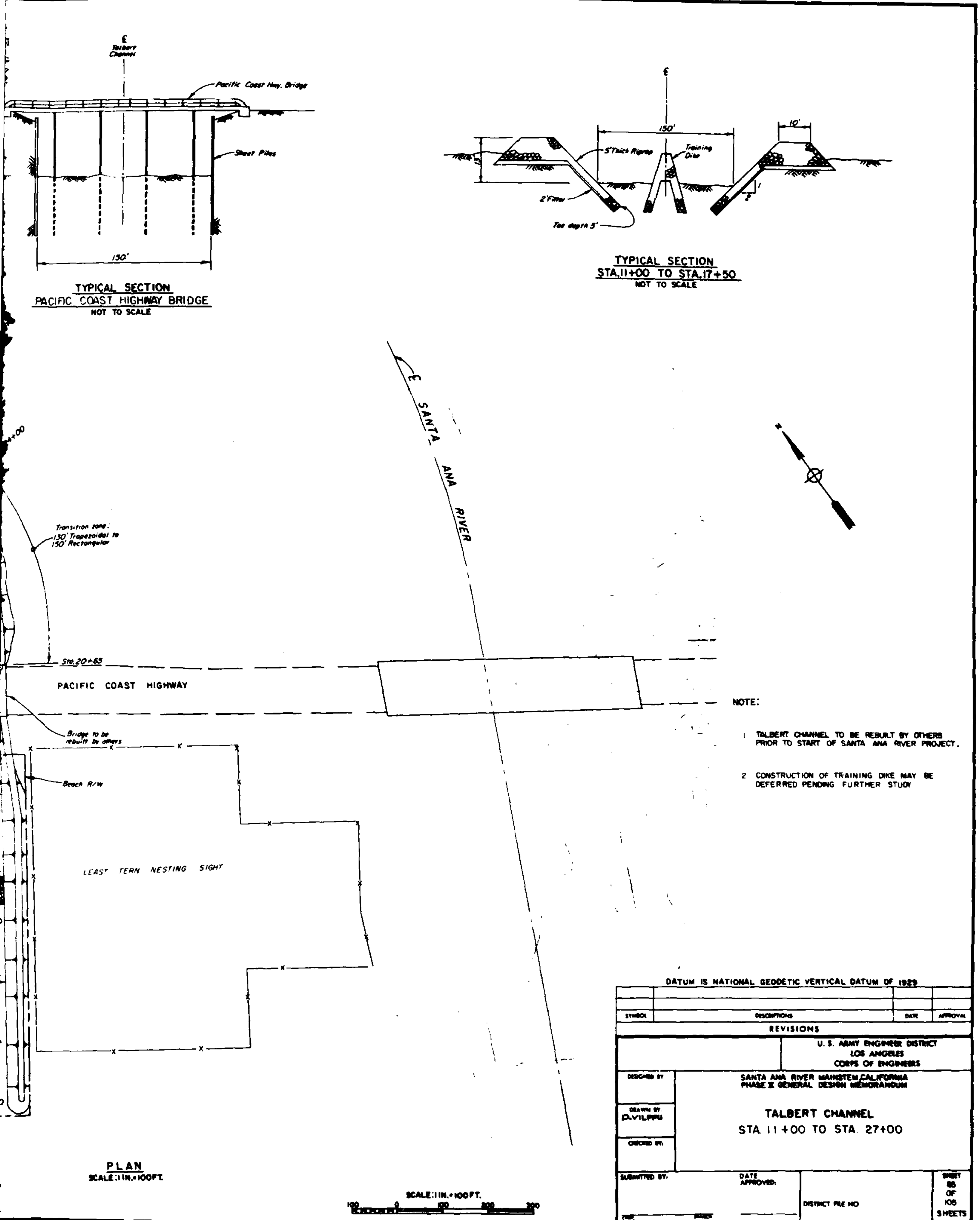
VALUE ENGINEERING PA



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY PAYS

UE ENGINEERING PAYS



TYPICAL SECTION
PACIFIC COAST HIGHWAY BRIDGE
NOT TO SCALE

TYPICAL SECTION
STA. 11+00 TO STA. 17+50
NOT TO SCALE

PLAN
SCALE: 1 IN. = 100 FT.

NOTE:

1. TALBERT CHANNEL TO BE REBUILT BY OTHERS PRIOR TO START OF SANTA ANA RIVER PROJECT.
2. CONSTRUCTION OF TRAINING DIKE MAY BE DEFERRED PENDING FURTHER STUDY

DATUM IS NATIONAL GEODETIC VERTICAL DATUM OF 1929

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DRAWN BY: D. VILLEPPU

TALBERT CHANNEL
STA. 11+00 TO STA. 27+00

CHECKED BY:

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 85 OF 105 SHEETS

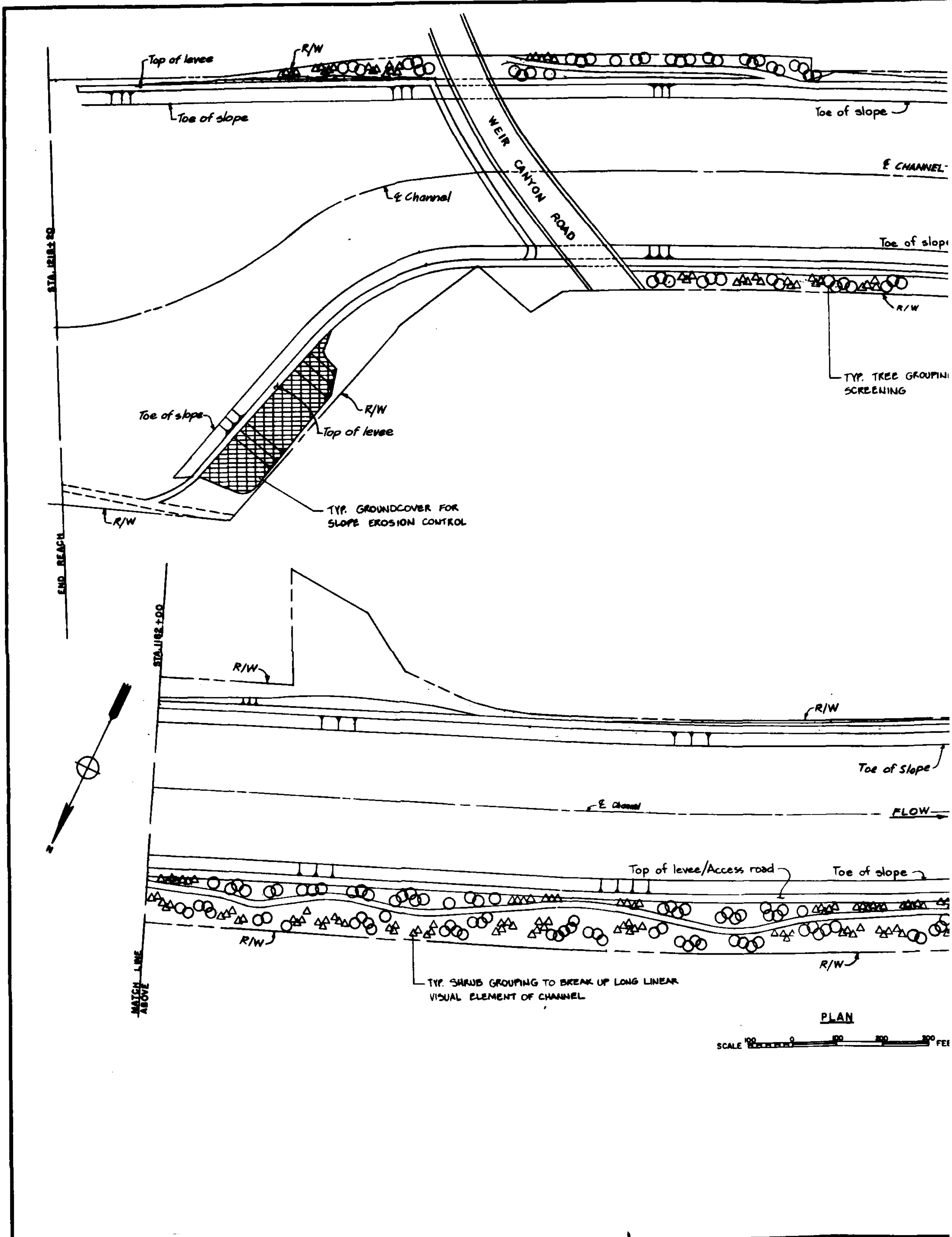
PLATE 66

SAFETY PAYS

1

2

VALUE ENGINEERI

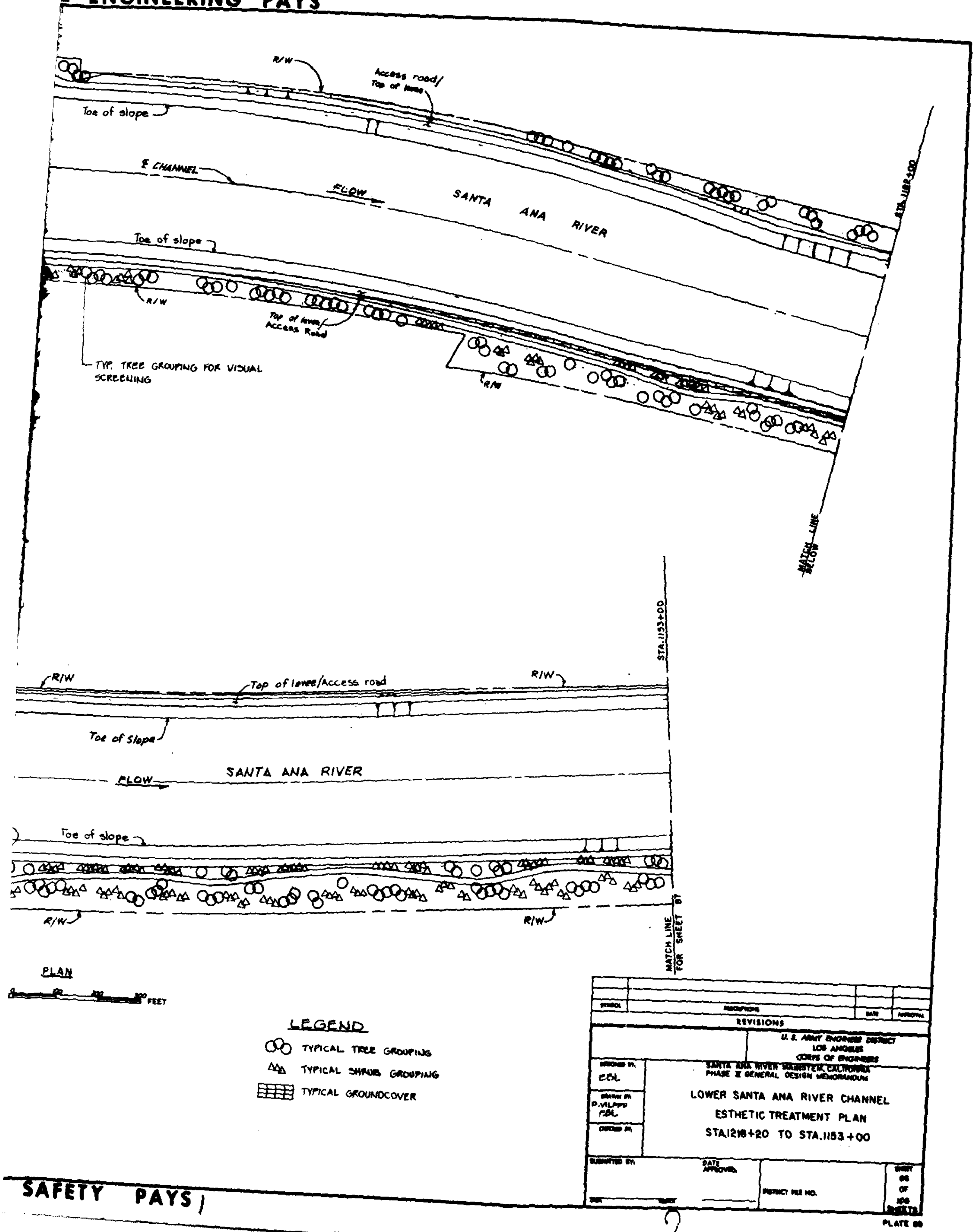


PLAN

SCALE 100 0 100 200 300 FEE

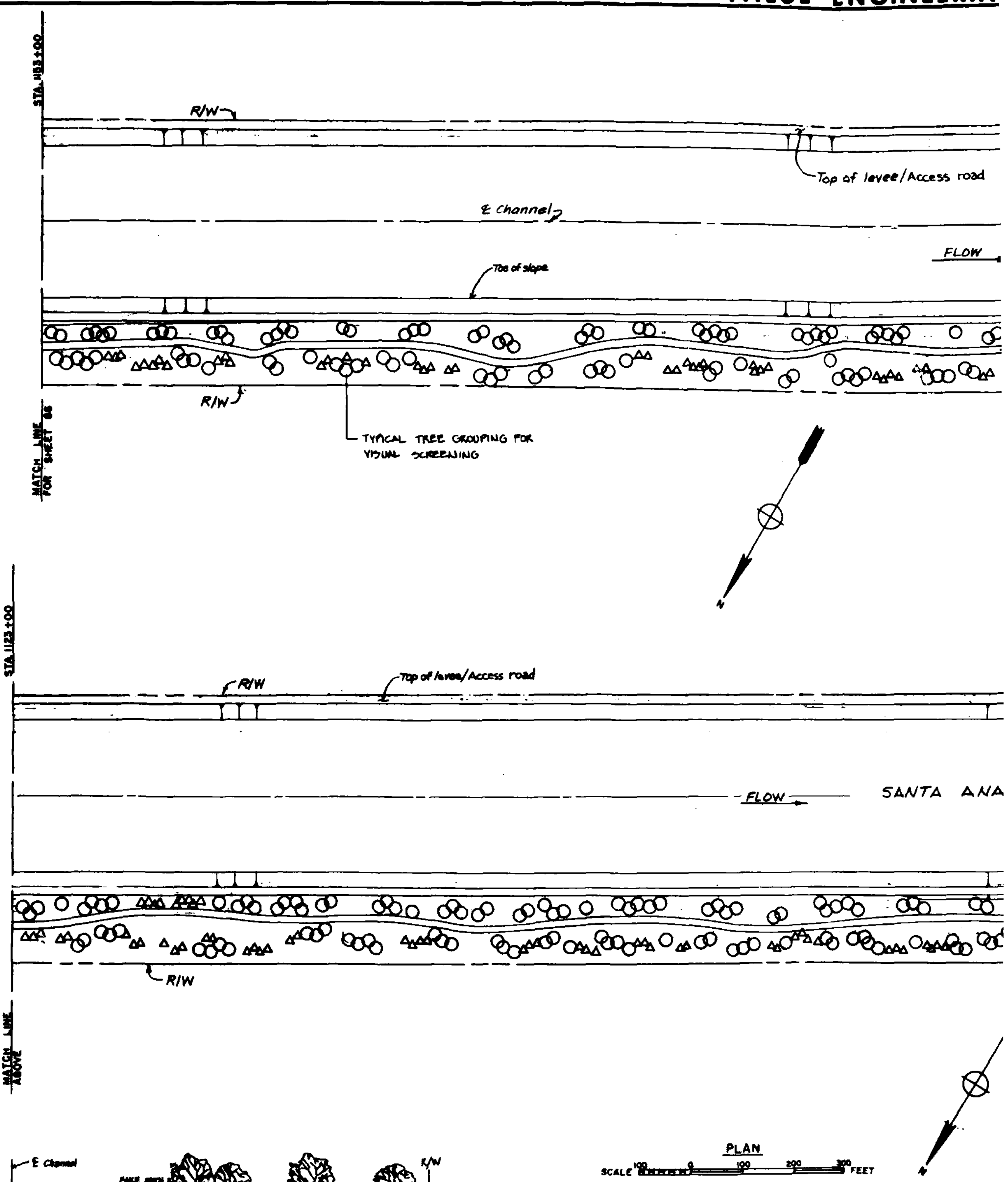
SAFETY P

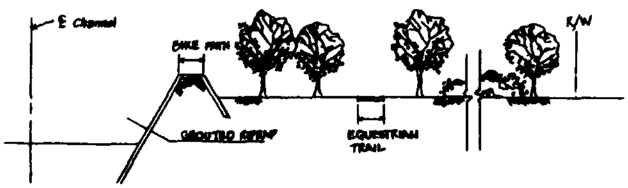
E ENGINEERING PAYS



SAFETY PAYS!

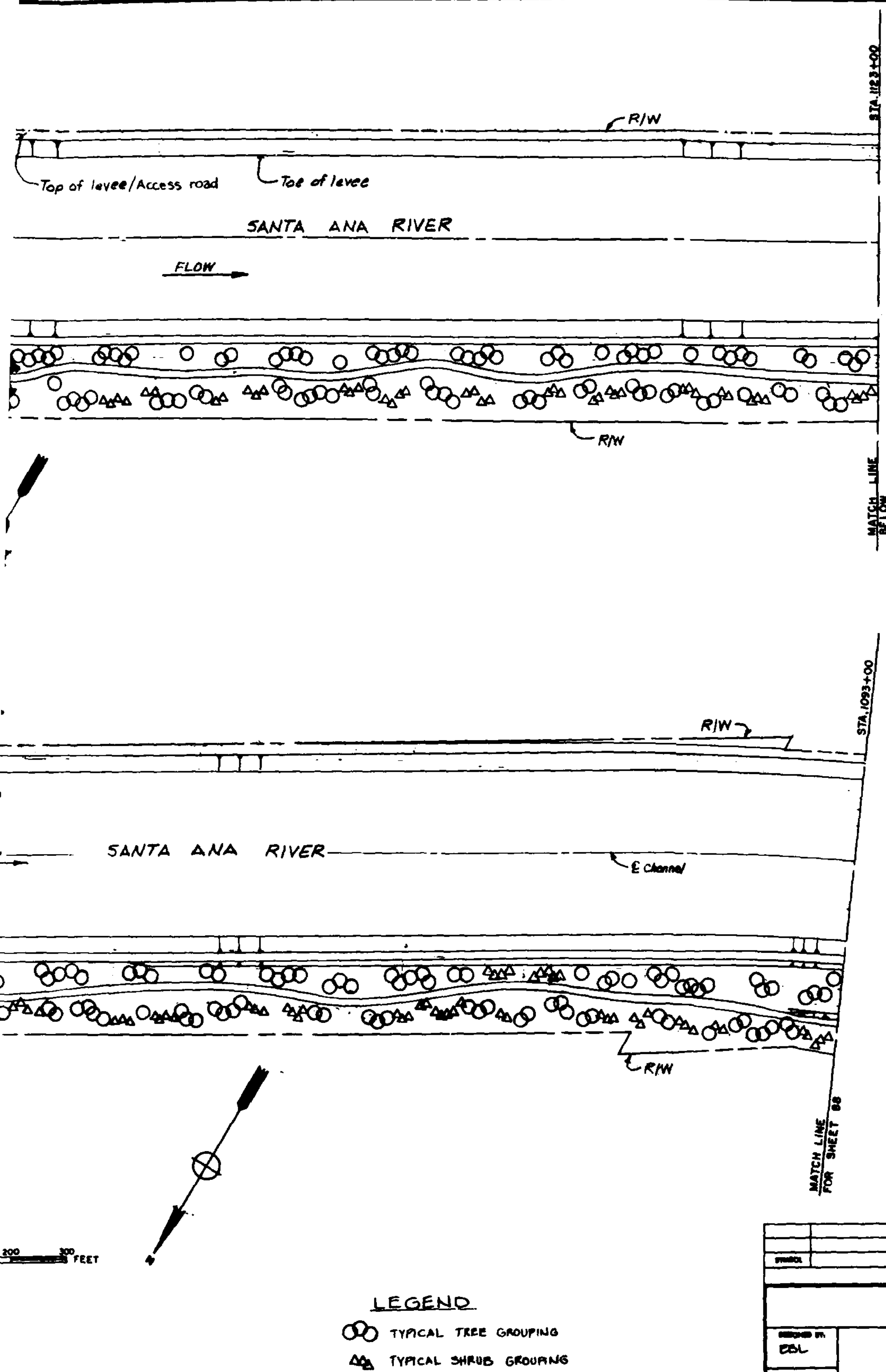
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





TYPICAL CROSS SECTION OF CHANNEL
W/ ESTHETIC TREATMENT N.T.S.

E ENGINEERING PAYS



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL
DRAWN BY: D.VILPPU EBL
CHECKED BY:

SANTA ANA RIVER, MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

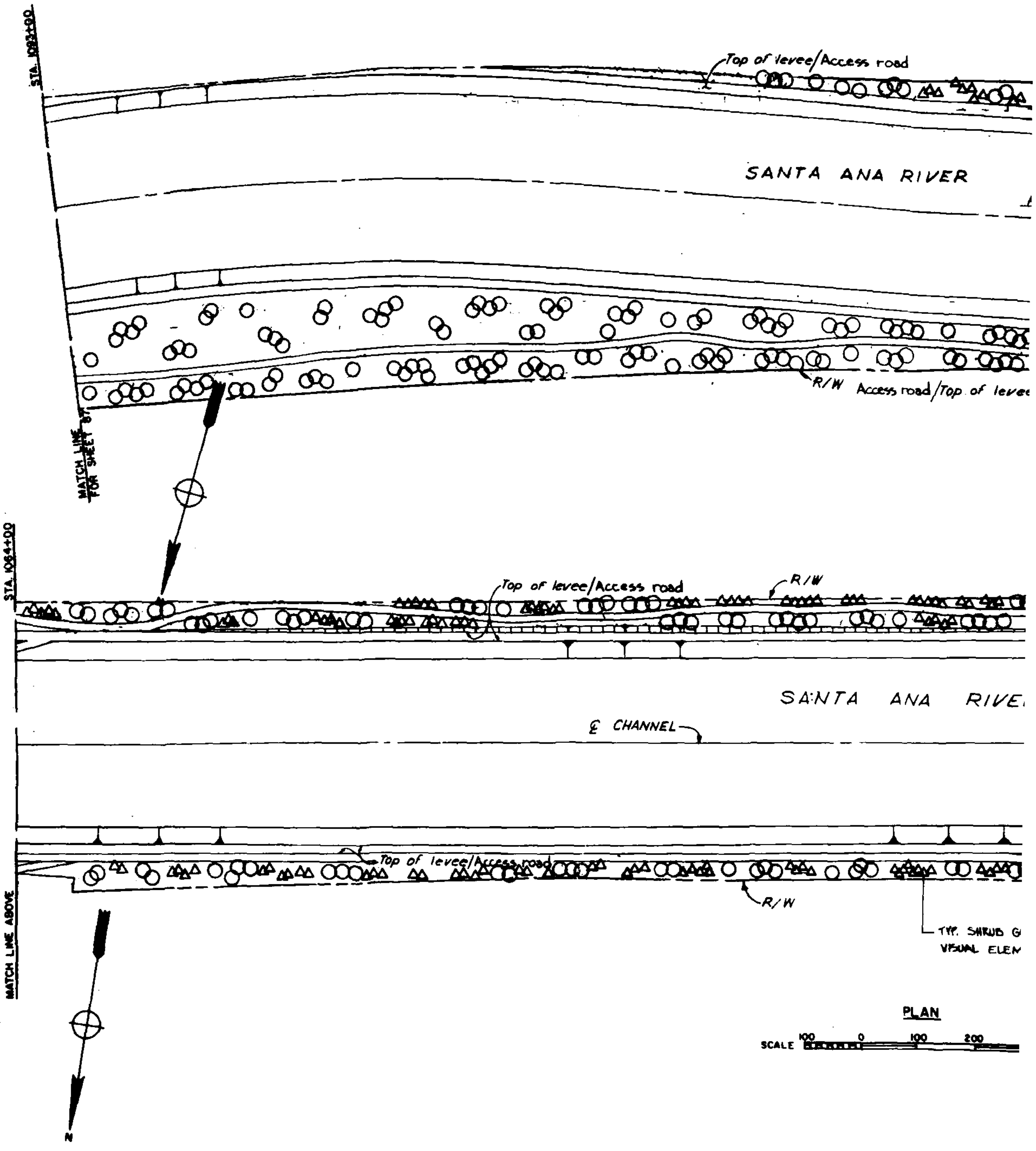
LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.1153+00 TO STA.1093+00

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 87 OF 108 SHEETS

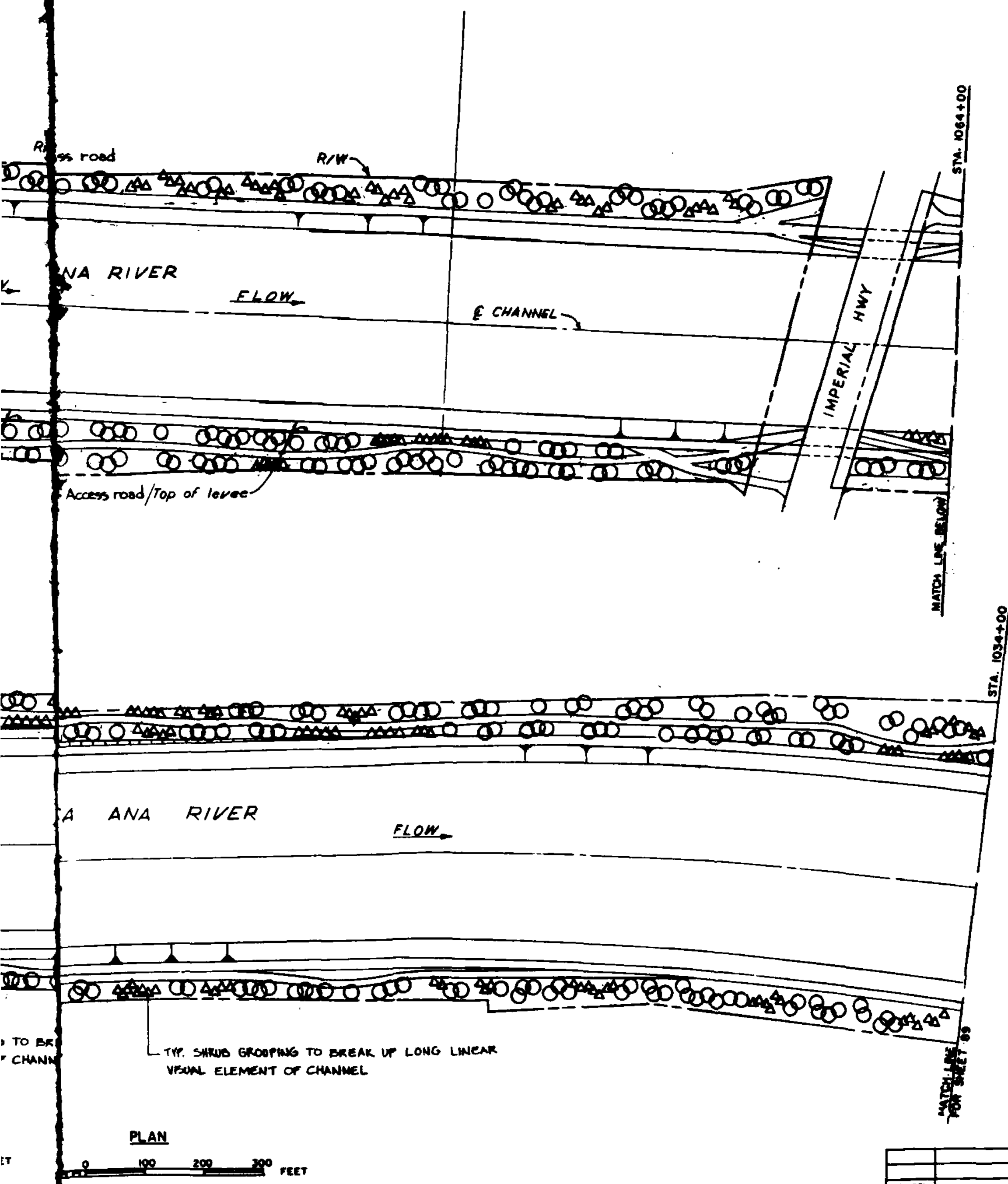
SAFETY PAYS

VALUE ENGINE

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



SAFETY



LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

DESIGNED BY: EBL

DRAWN BY: H.B. EBL

CHECKED BY:

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA. 1093+00 TO STA. 1034+00

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

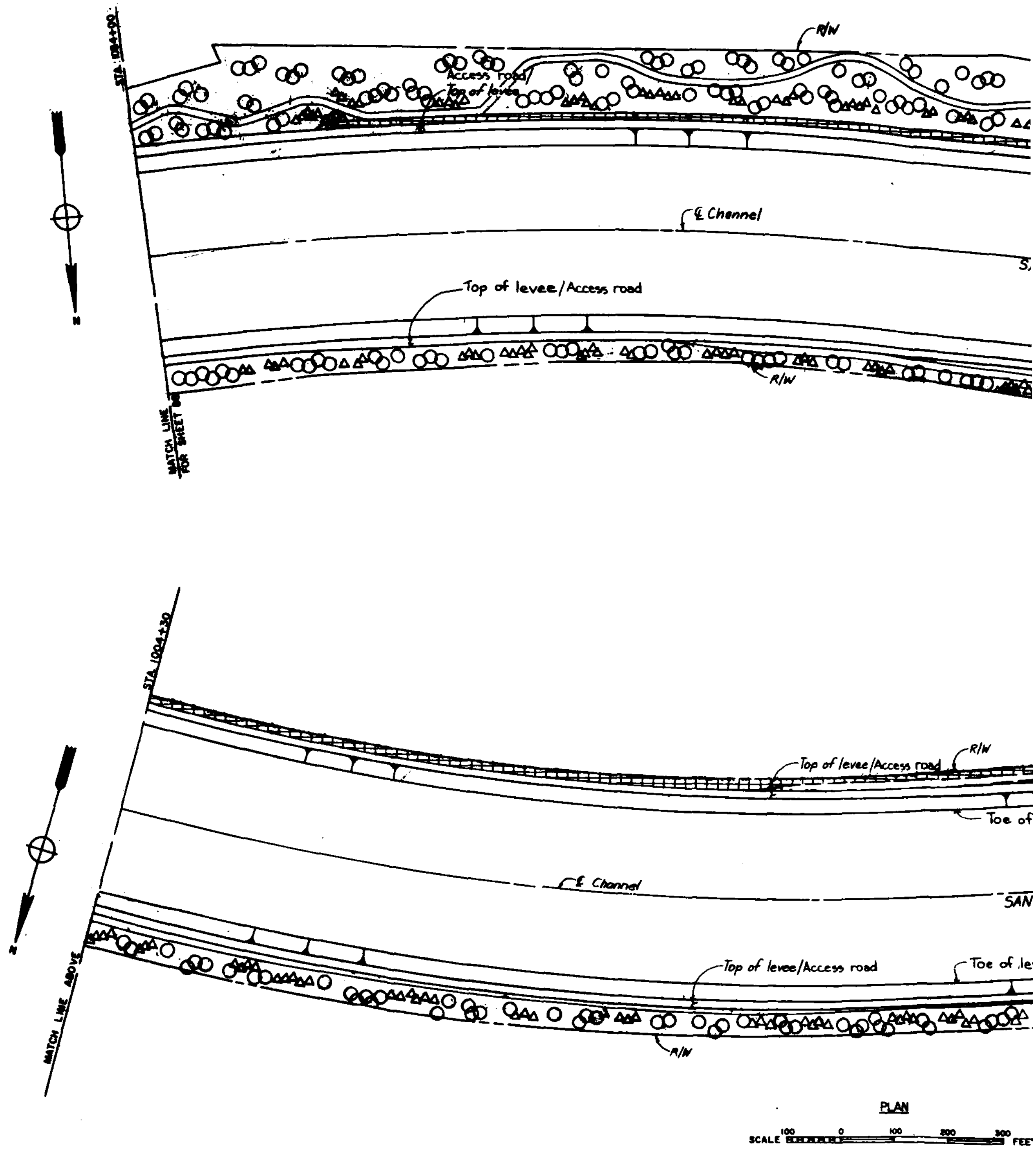
SHEET 88 OF 105 SHEETS

PLATE 91

2

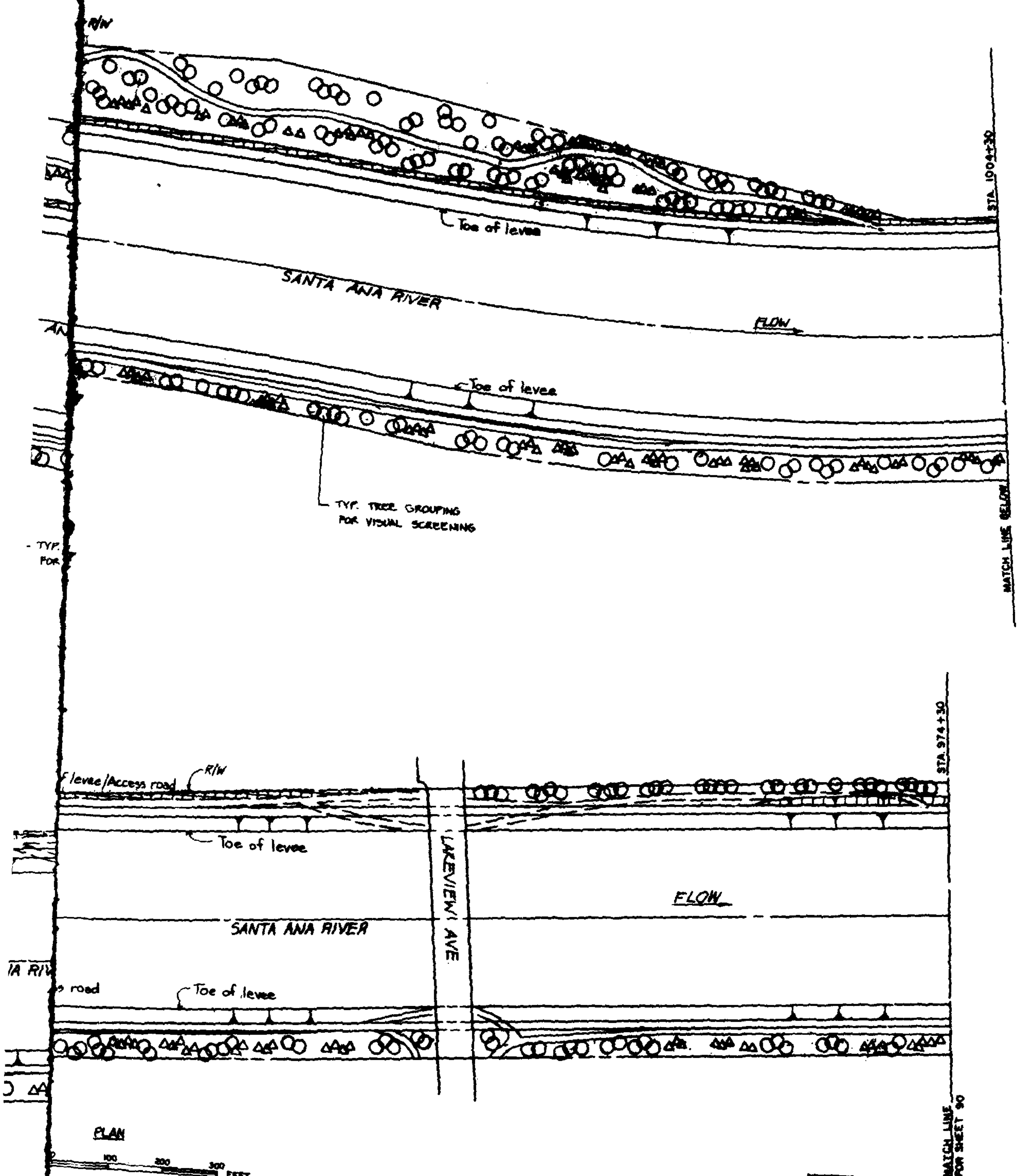
VALUE ENGINEI

ENVIRONMENTAL ENHANCEMENT THRU. ENGINEERING



SAFETY

VALUE ENGINEERING PAYS



LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

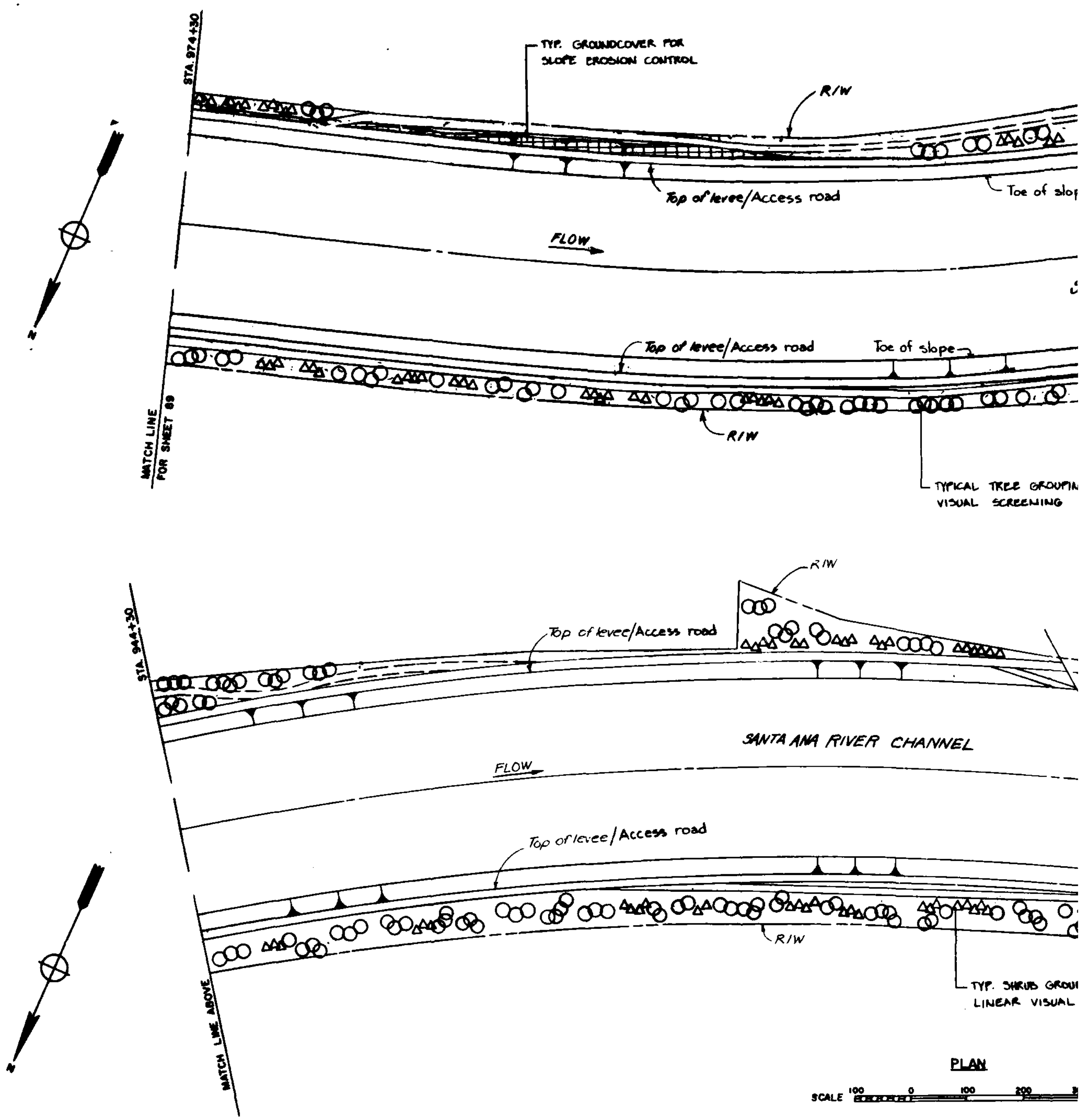
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA 1034+00 TO STA. 974+30

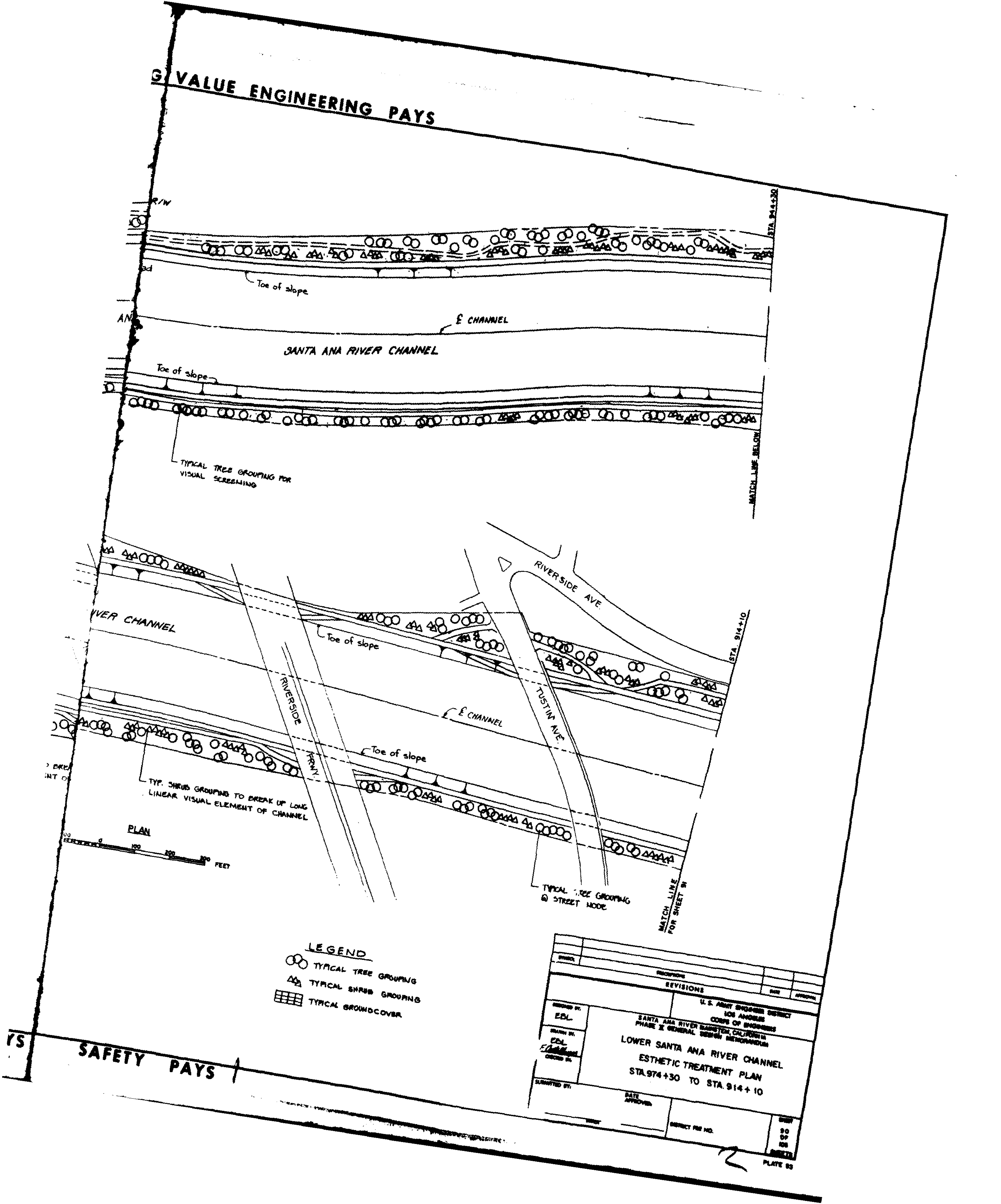
EBL
EBL

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 89 OF 105 SHEETS
PLATE 92

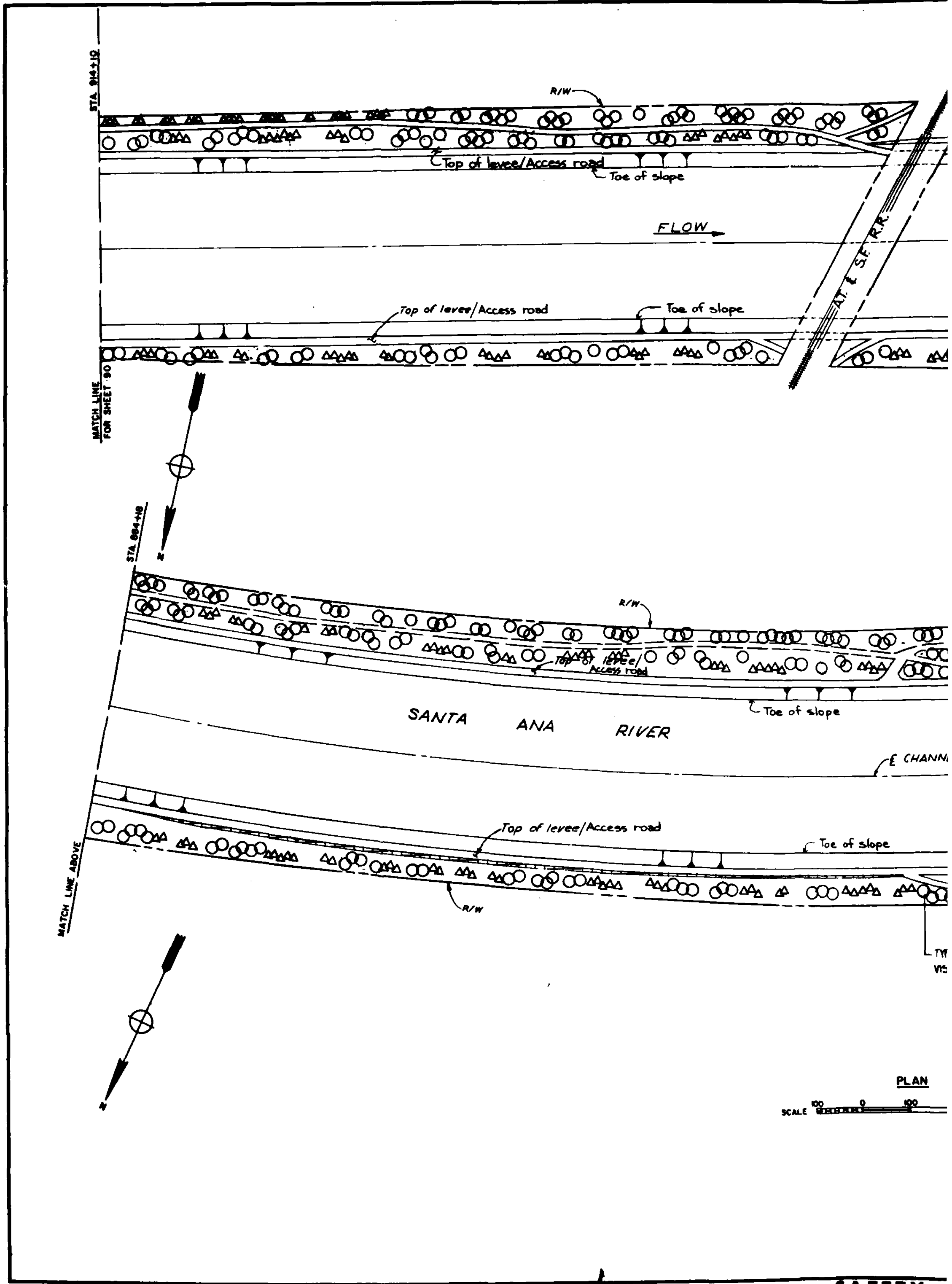
SAFETY PAYS



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

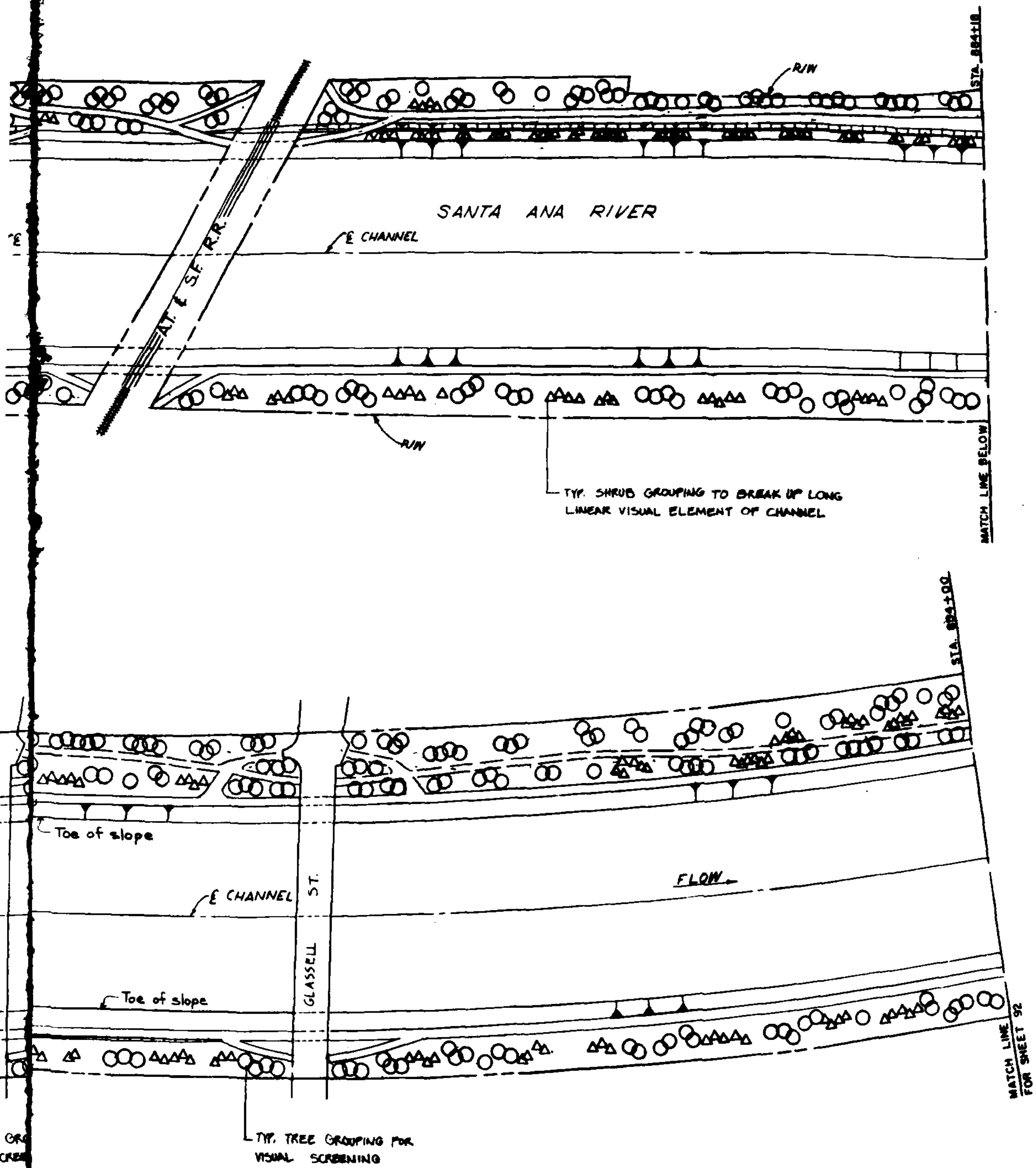

VALUE ENGINEERING PAYS
R/W
STA. 974+30
Toe of slope
℄ CHANNEL
SANTA ANA RIVER CHANNEL
Toe of slope
TYPICAL TREE GROUPING FOR VISUAL SCREENING
MATCH LINE BELOW
RIVERSIDE AVE.
RIVER CHANNEL
Toe of slope
RIVERSIDE FRWY
TUSTIN AVE.
STA. 914+10
℄ CHANNEL
Toe of slope
TYP. SHRUB GROUPING TO BREAK UP LONG LINEAR VISUAL ELEMENT OF CHANNEL
PLAN
0
100
200
300
FEET
TYPICAL TREE GROUPING @ STREET NODE
MATCH LINE FOR SHEET 91
LEGEND
TYPICAL TREE GROUPING
TYPICAL SHRUB GROUPING
TYPICAL GROUNDCOVER
SAFETY PAYS
REVISIONS
EBL
EBL
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS
SANTA ANA RIVER BASIN, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM
LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA. 974+30 TO STA. 914+10
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

VALUE ENGINEE



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY



PLAN

SCALE 100 0 100 200 300 FEET

LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTION	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: CBL

DRAWN BY: H.B. CBL

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA. 914+10 TO STA. 854+00

SUBMITTED BY:

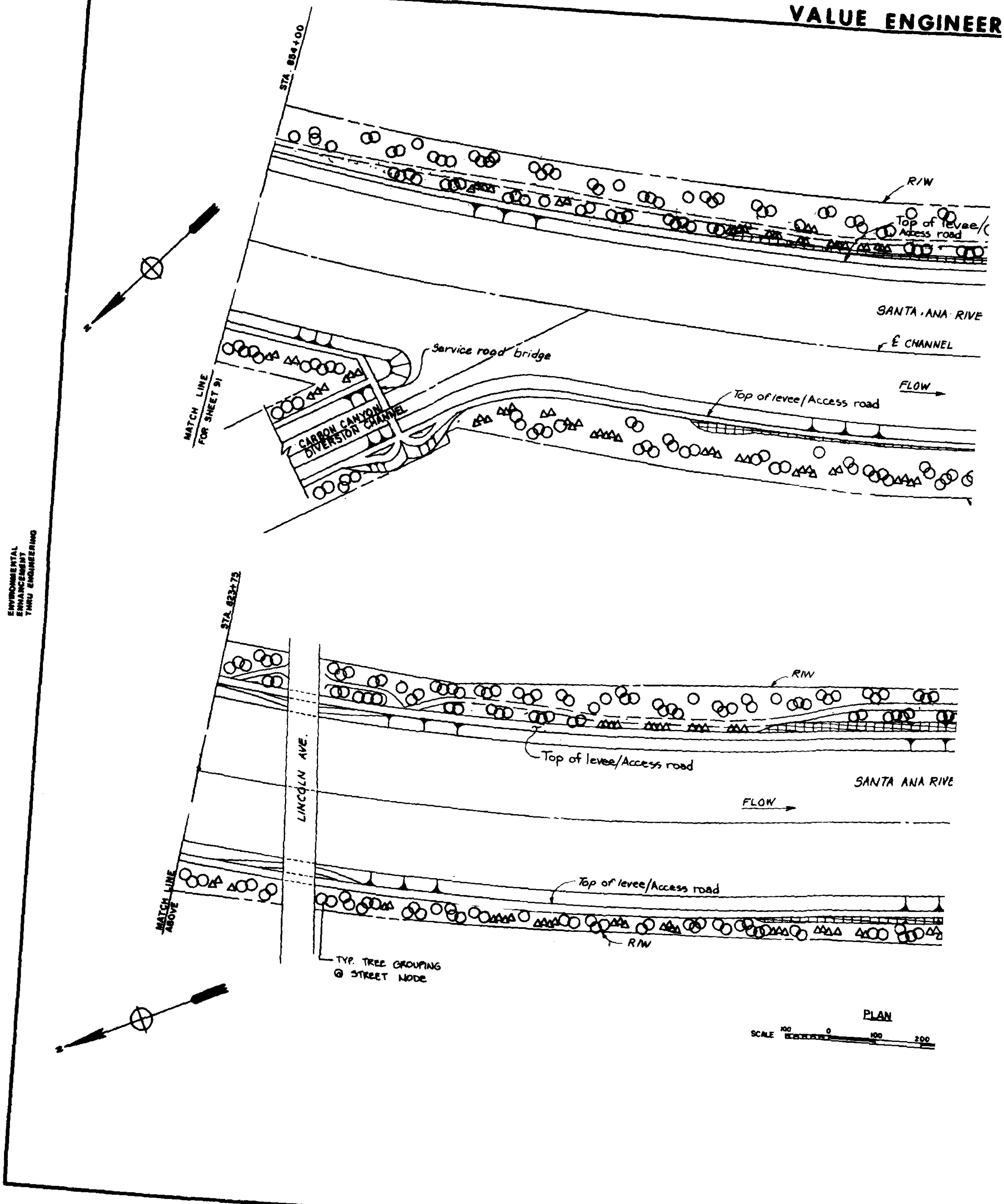
DATE APPROVED:

DISTRICT FILE NO.

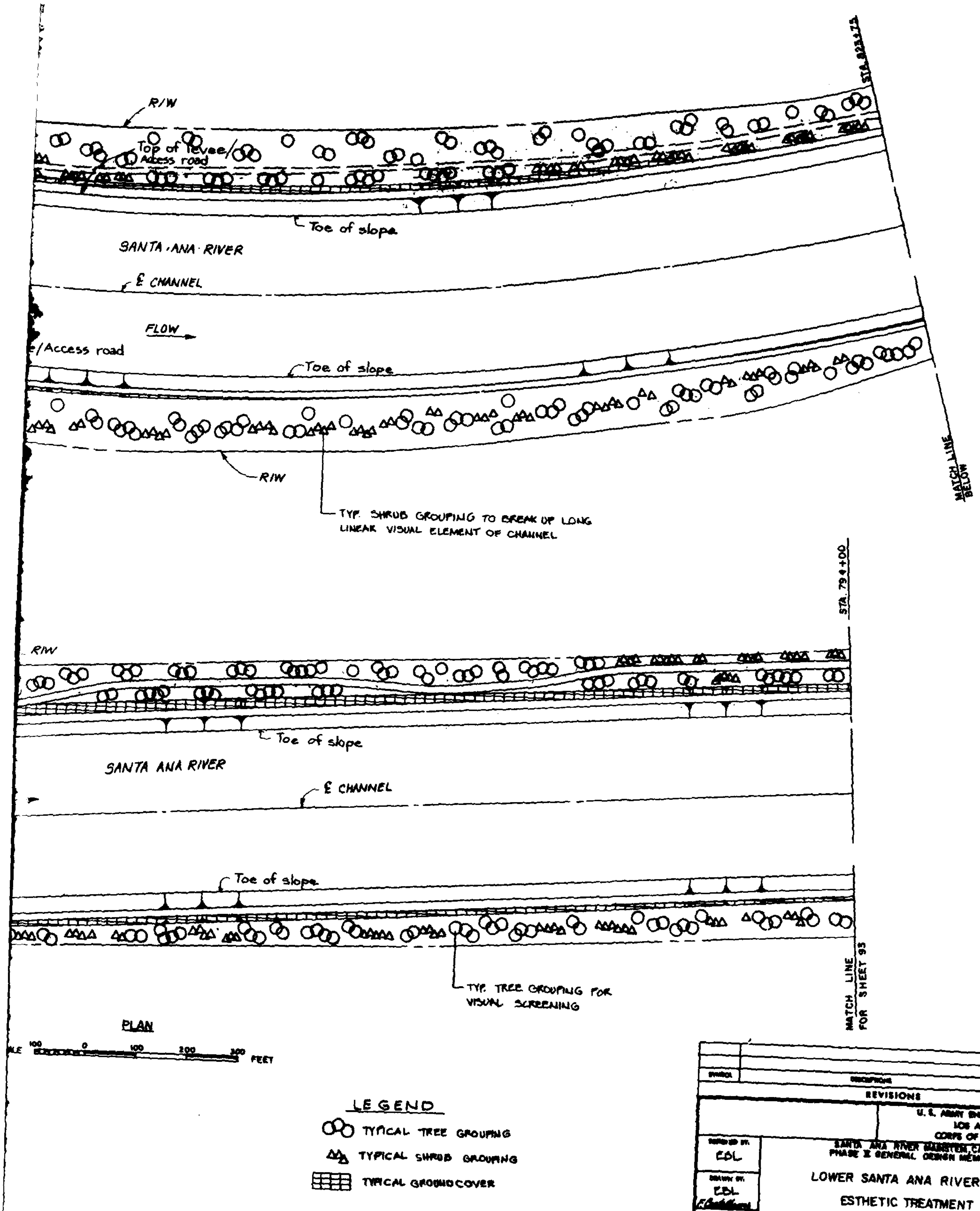
SHEET 91 OF 105 SHEETS

PLATE 94

VALUE ENGINEER



SAFETY P



REVISIONS

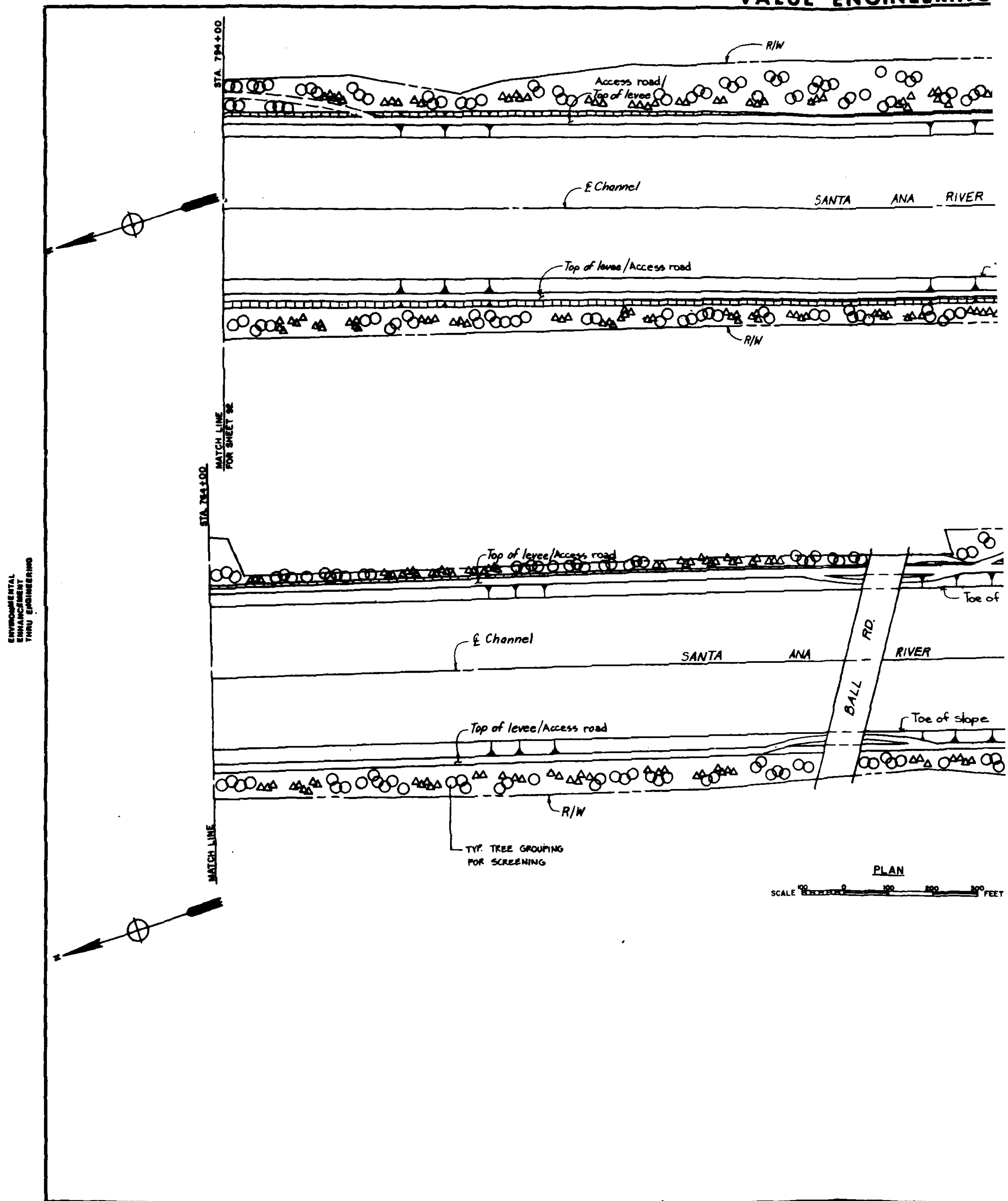
U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

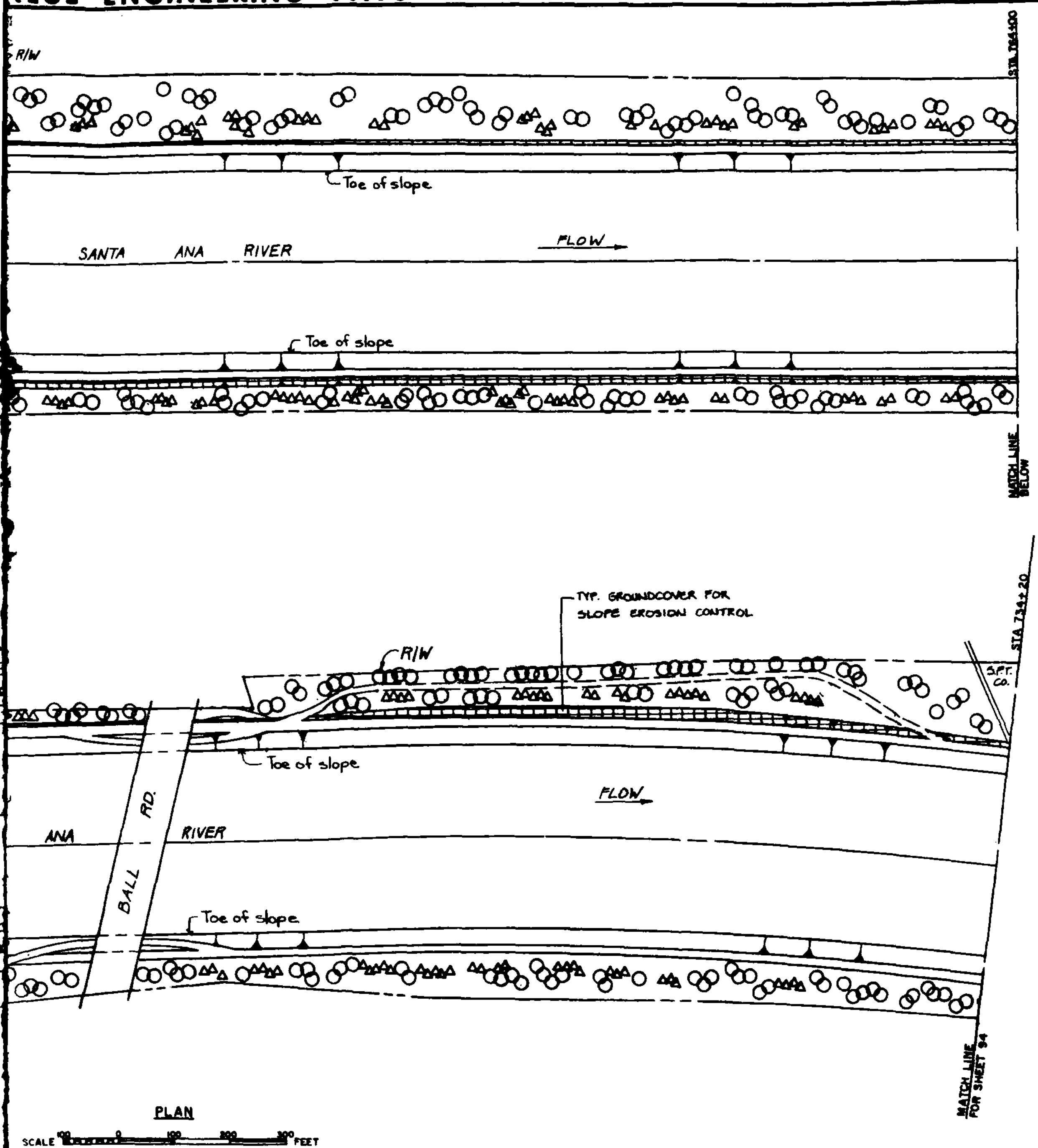
LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.854+00 TO STA.794+00

DESIGNED BY: EBL
DRAWN BY: EBL
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 92 OF 100 SHEETS
PLATE 95

2



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING
STA. 794+00
R/W
Access road/
Top of levee
℄ Channel
SANTA ANA RIVER
Top of levee/Access road
R/W
MATCH LINE
FOR SHEET 92
STA. 784+00
Top of levee/Access road
Toe of
℄ Channel
SANTA ANA RIVER
BALL RD.
Toe of slope
Top of levee/Access road
R/W
MATCH LINE
TYP. TREE GROUPING
FOR SCREENING
PLAN
SCALE 100 0 100 200 300 FEET



LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL
DRAWN BY: EBL, F. ALVARADO
CHECKED BY:

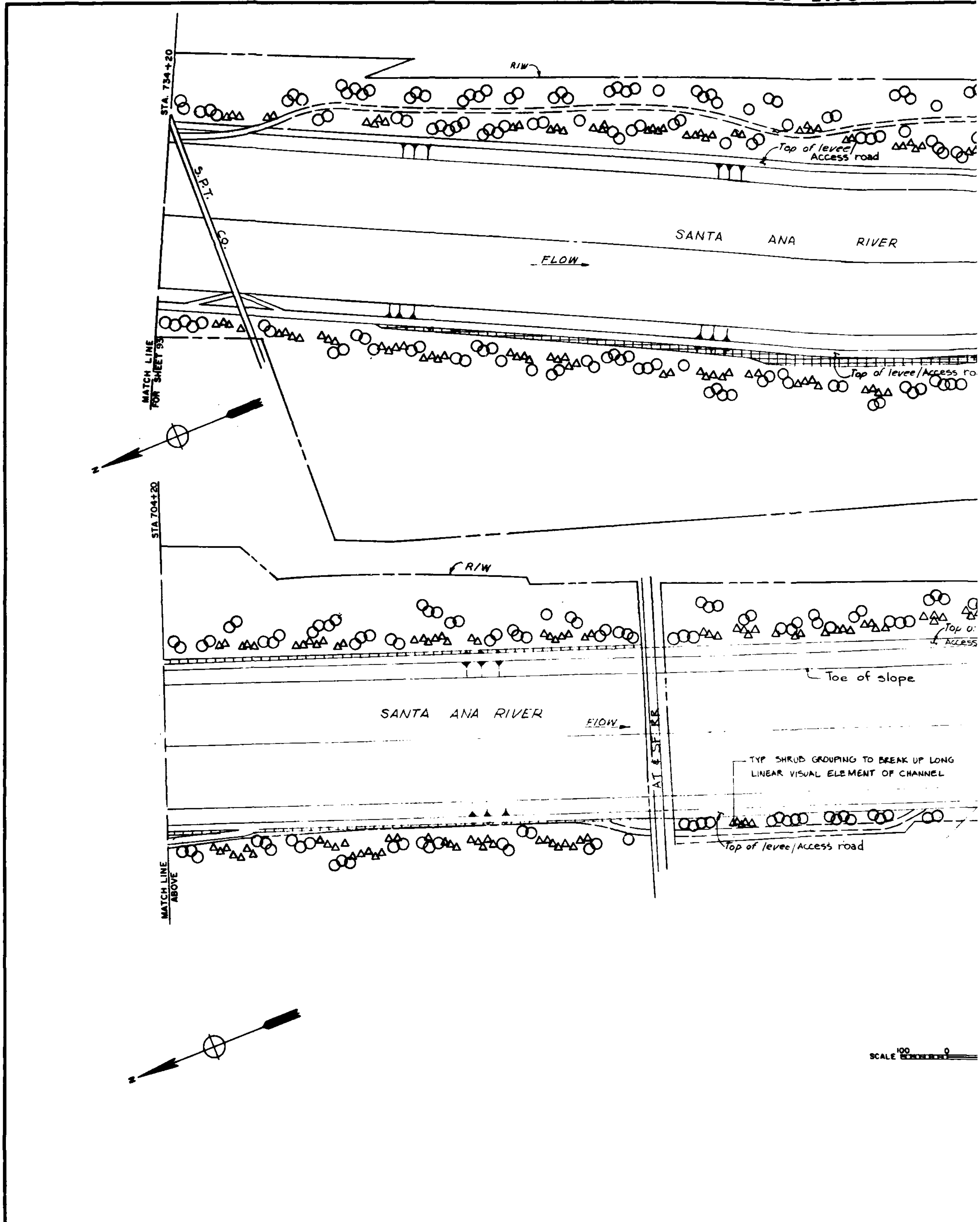
SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

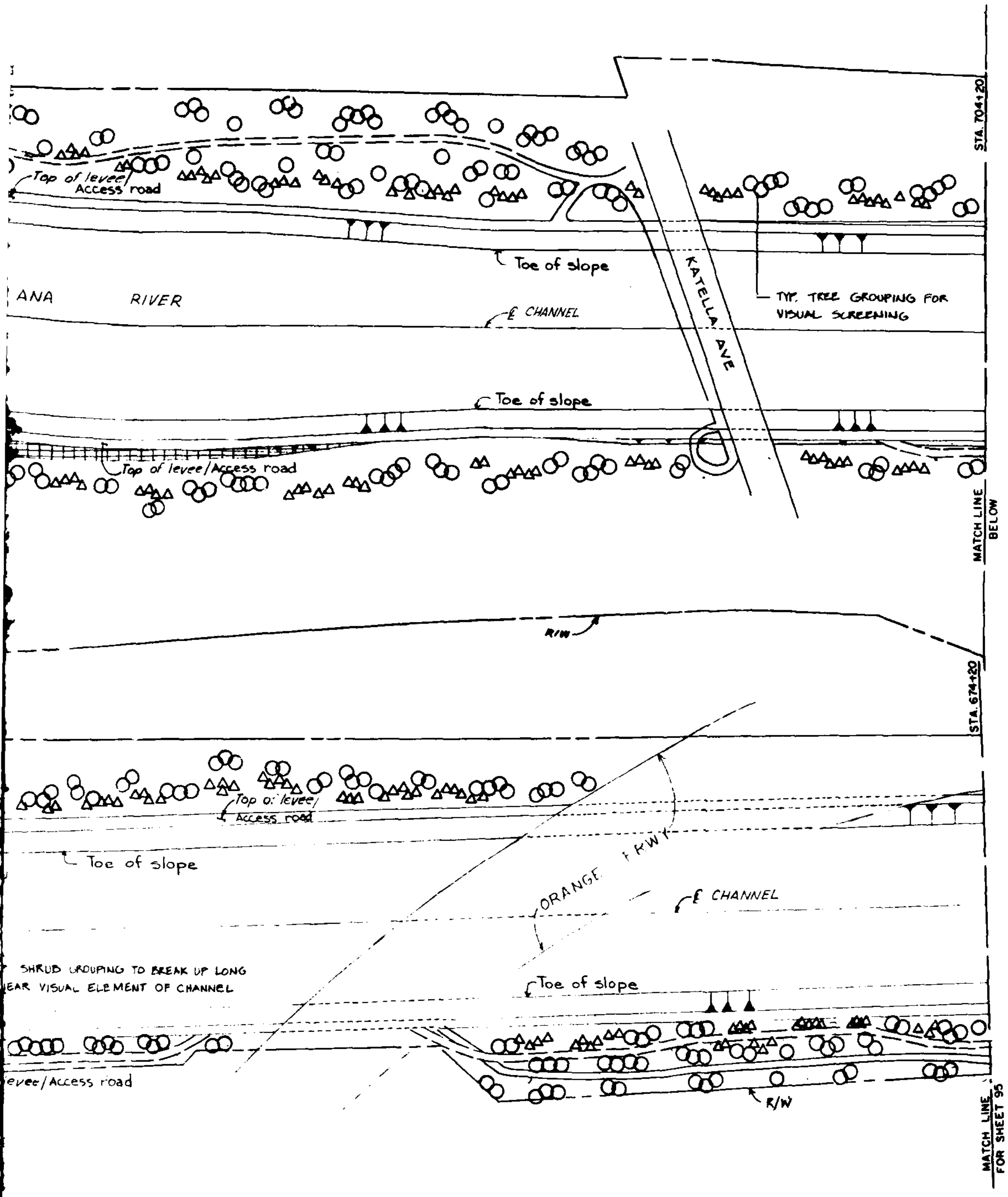
LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA. 794+00 TO STA. 734+20

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 93 OF 108 SHEETS

PLATE 96

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





PLAN

SCALE 100 0 100 200 300 FEET

LEGEND

TYPICAL TREE GROUPING

TYPICAL SHRUB GROUPING

TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: H-96

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA. 734+20 TO STA. 674+20

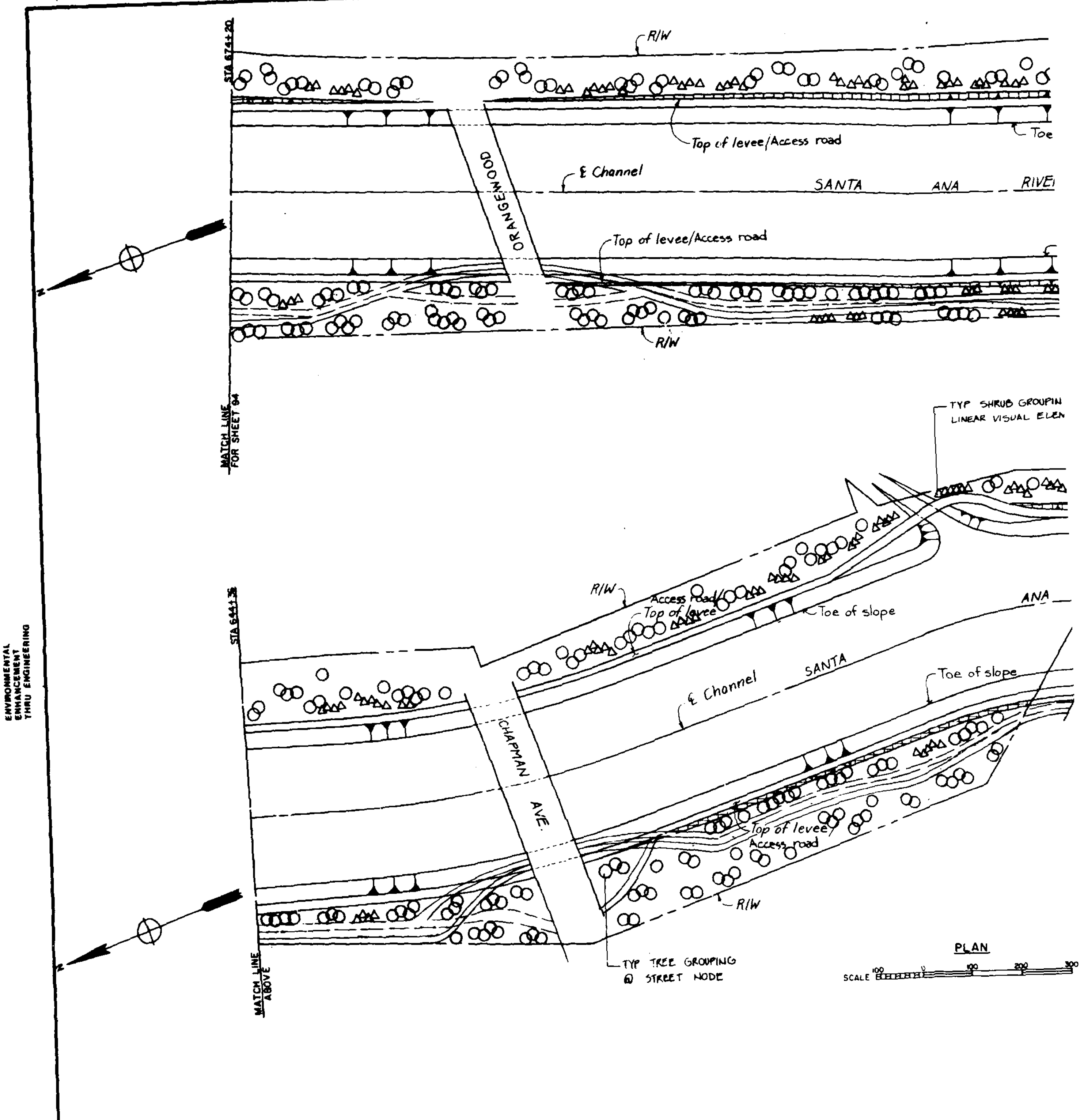
SUBMITTED BY:

DATE APPROVED:

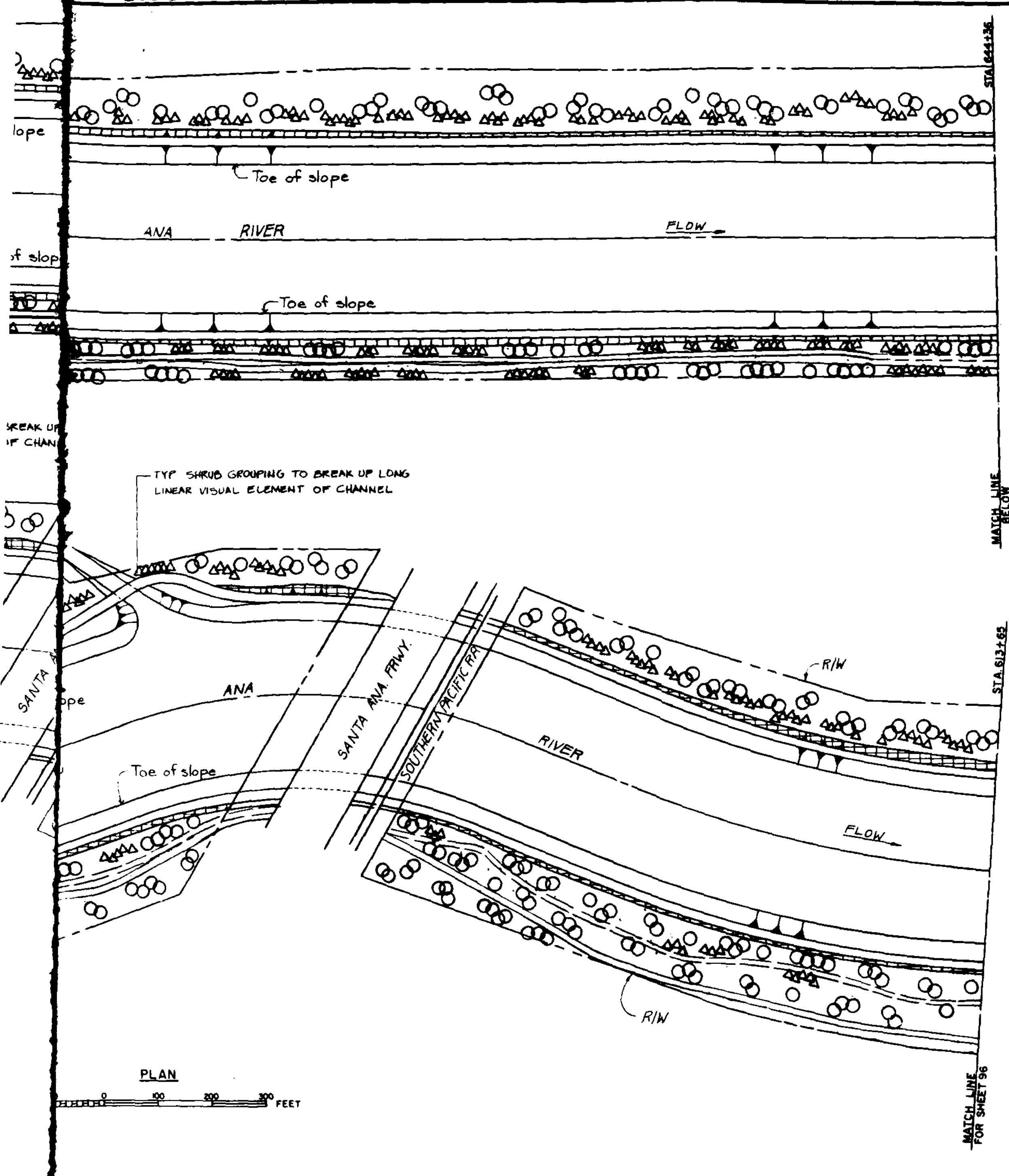
DISTRICT FILE NO.

SHEET 94 OF 108 SHEETS

PLATE 7


STA 674+20
R/W
Top of levee/Access road
Toe
℄ Channel
SANTA ANA RIVE
ORANGEWOOD
Top of levee/Access road
R/W
MATCH LINE FOR SHEET 94
TYP SHRUB GROUPIN
LINEAR VISUAL ELEM
STA 644+36
R/W
Access road/
Top of levee
Toe of slope
ANA
SANTA
℄ Channel
Toe of slope
CHAPMAN
AVE.
Top of levee/
Access road
R/W
TYP TREE GROUPING
@ STREET NODE
PLAN
SCALE 100 0 100 200 300
MATCH LINE ABOVE
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

UE ENGINEERING PAYS



LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL
DRAWN BY: EBL
CHECKED BY:

SANTA ANA RIVER, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.674+20 TO STA.613+65

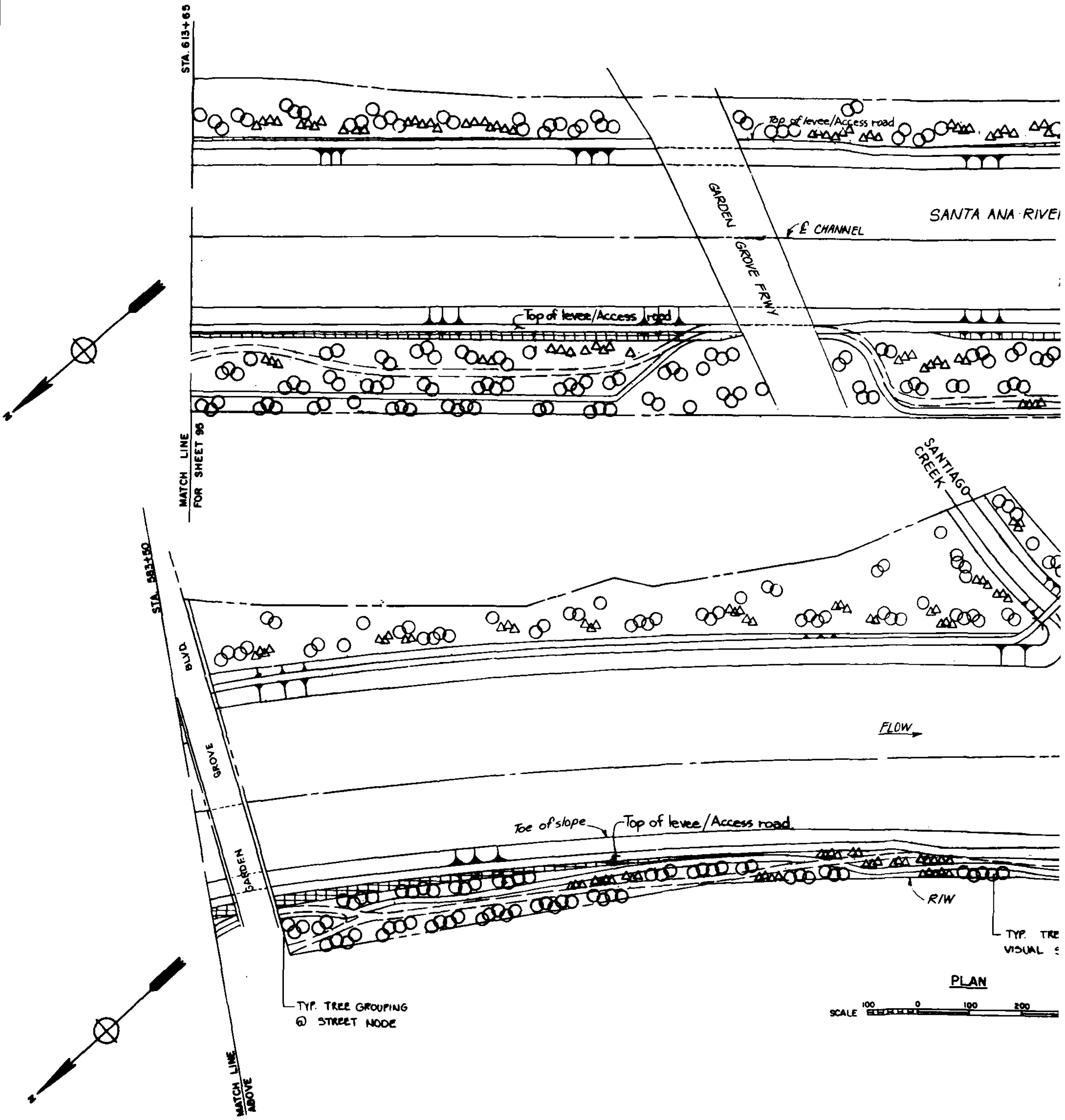
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.

SHEET 95 OF 106 SHEETS
PLATE 95

SAFETY PAYS

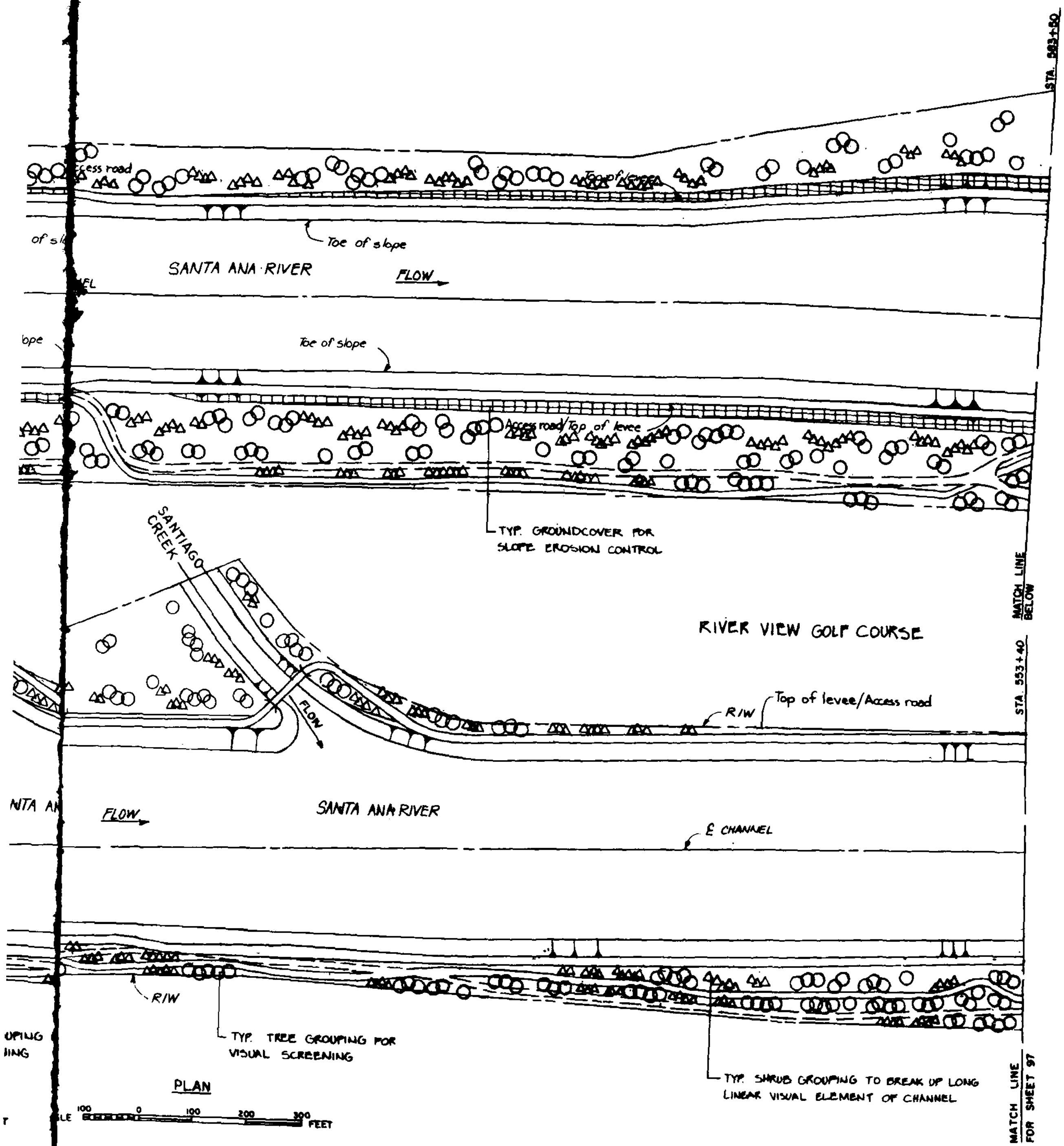
VALUE ENGINEER

ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING



SAFETY PA

LUE ENGINEERING PAYS



LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

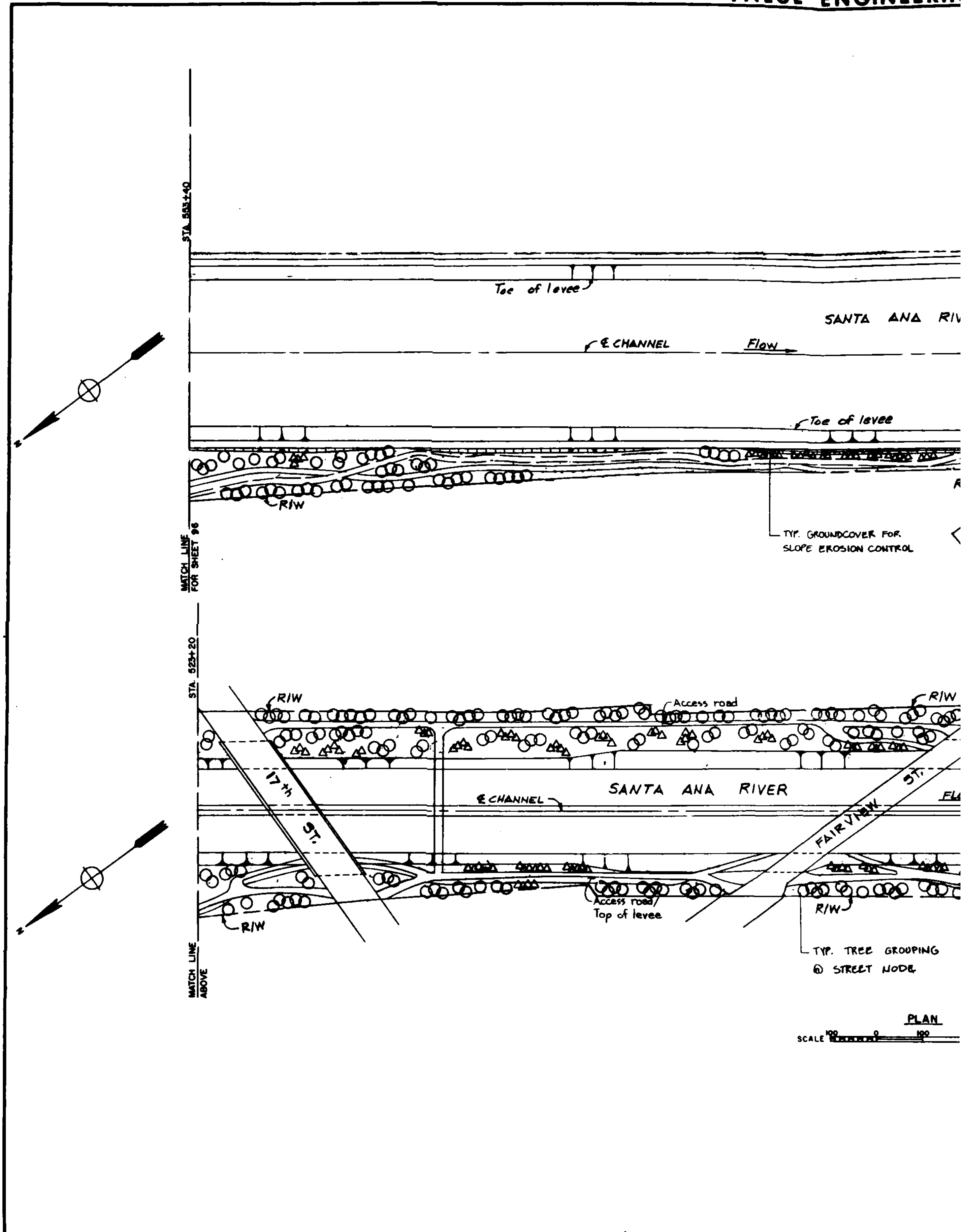
LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA 613+65 TO STA. 553+40

DESIGNED BY: EBL
DRAWN BY: EBL
CHECKED BY:
SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 96 OF 105 SHEETS

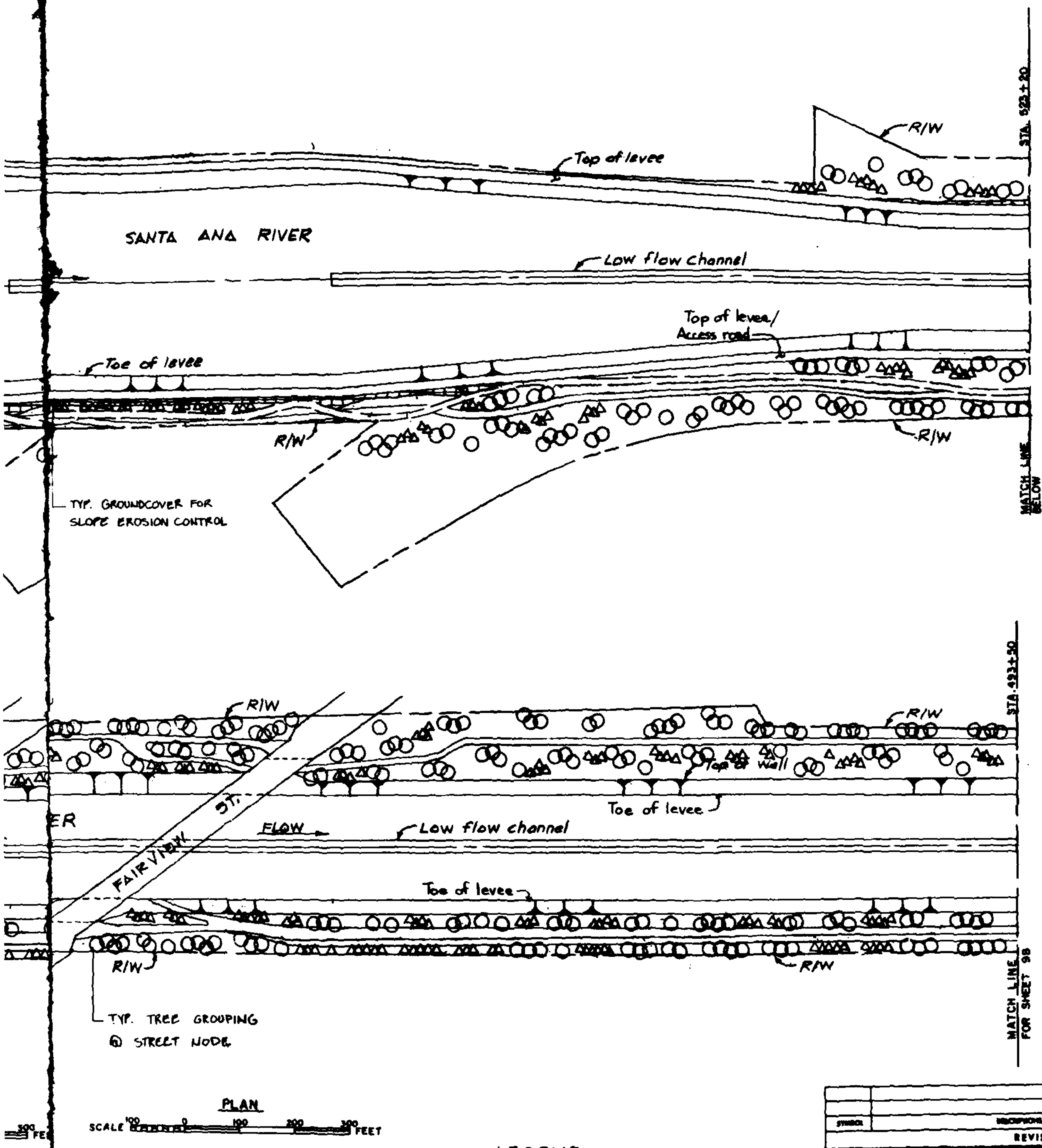
SAFETY PAYS

VALUE ENGINEERIN

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



SAFETY PA



LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL

DRAWN BY: D.VILPPU EBL

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.553+40 TO STA.493+50

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

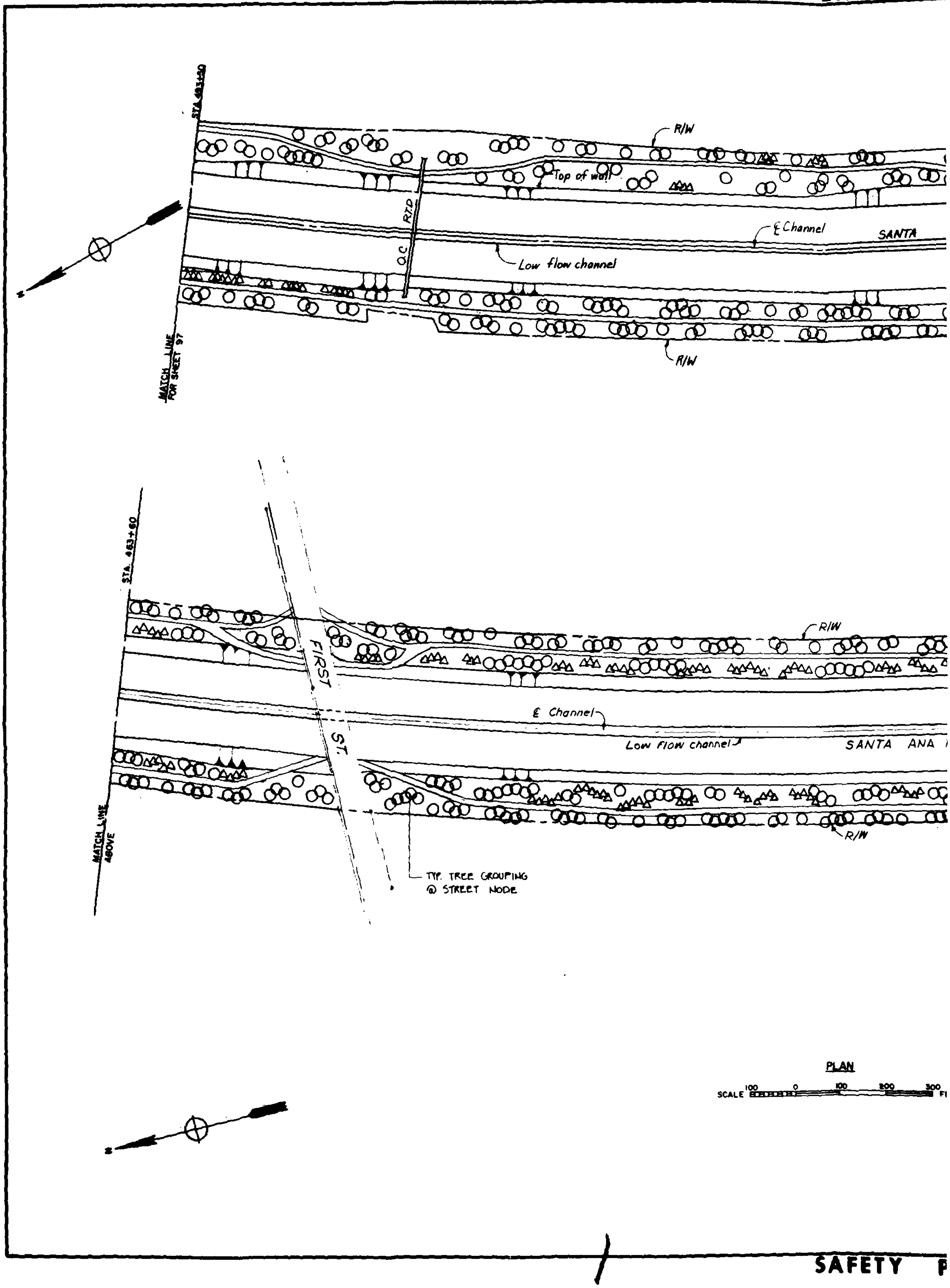
SHEET 97 OF 105 SHEETS

PLATE 100

2

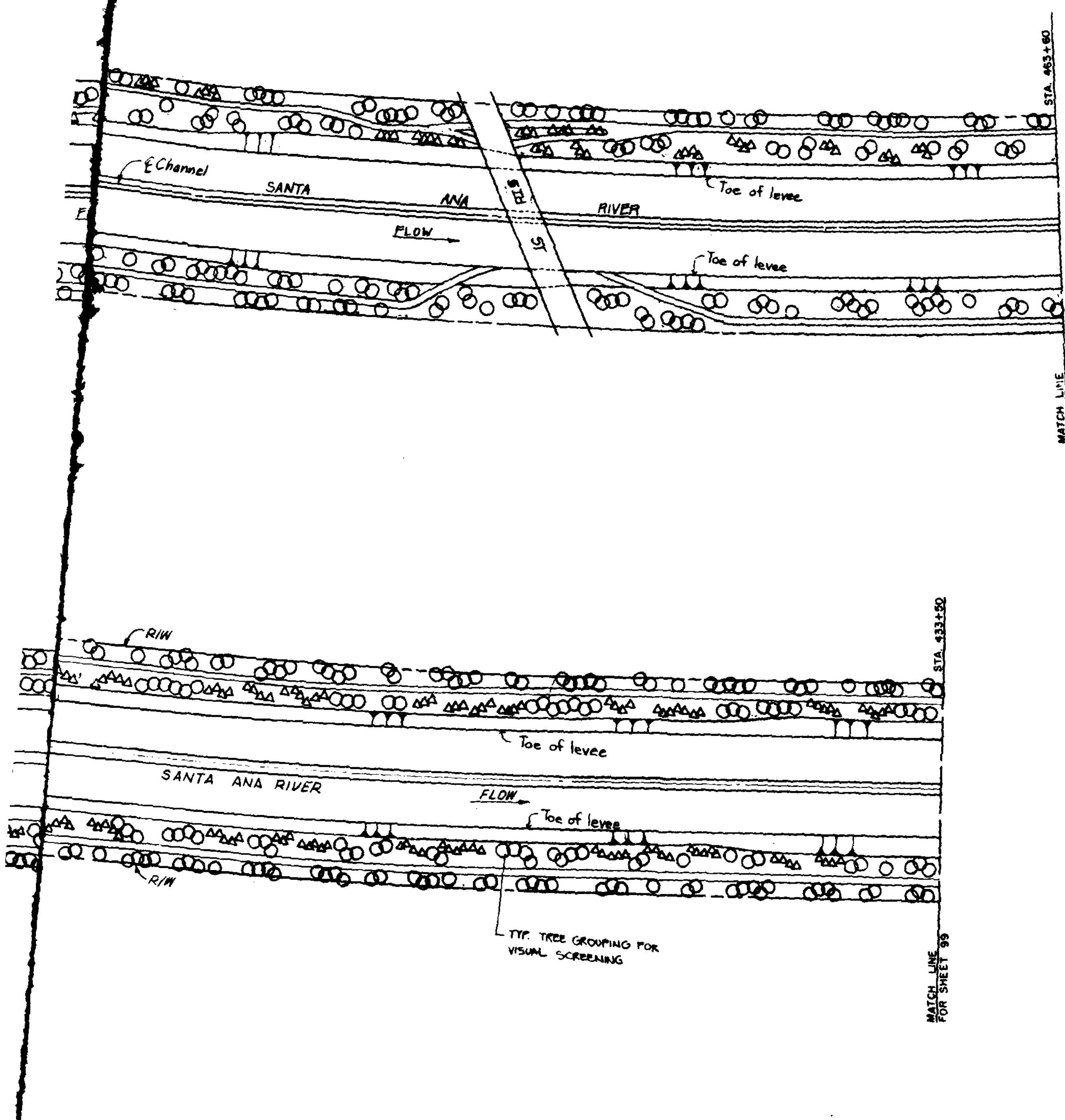
VALUE ENGINEERI

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



SAFETY F

VALUE ENGINEERING PAYS



PLAN

0 100 200 300 FEET

LEGEND

TYPICAL TREE GROUPING

TYPICAL SHRUB GROUPING

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL

DRAWN BY: H. B.

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA 493+50 TO STA. 433+50

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

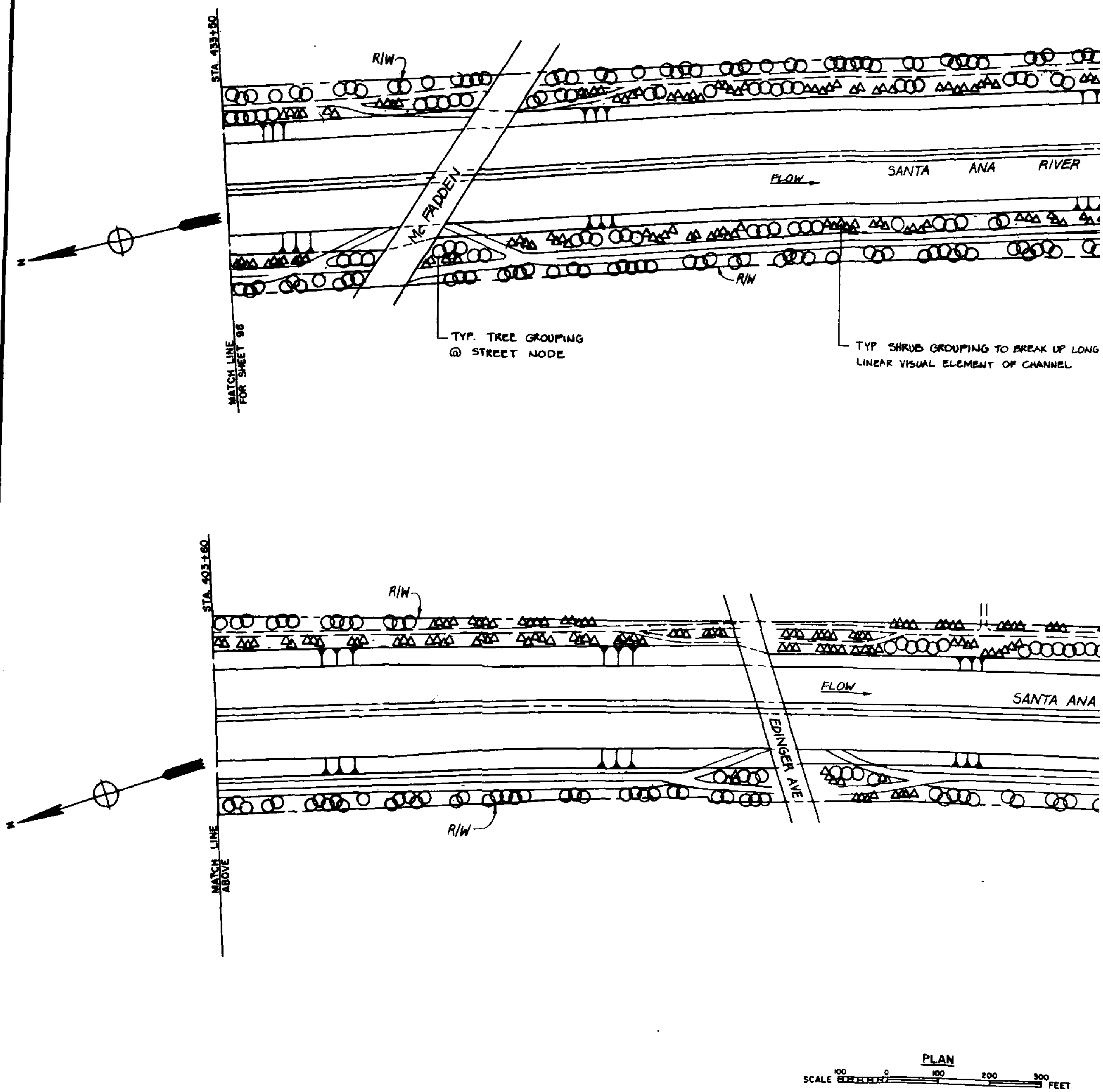
SHEET 98 OF 105 SHEETS

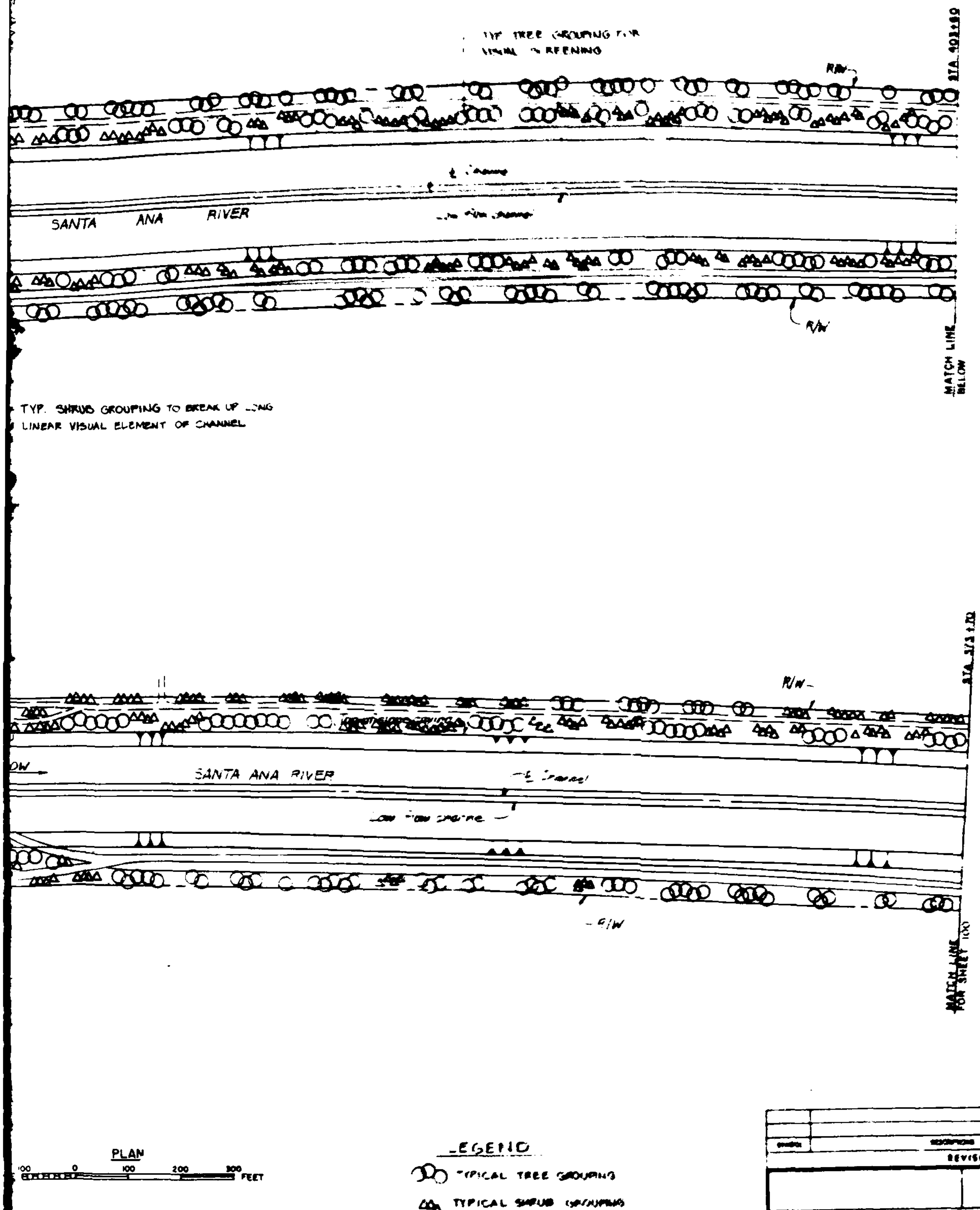
PLATE 101

SAFETY PAYS

2

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING





REVISIONS

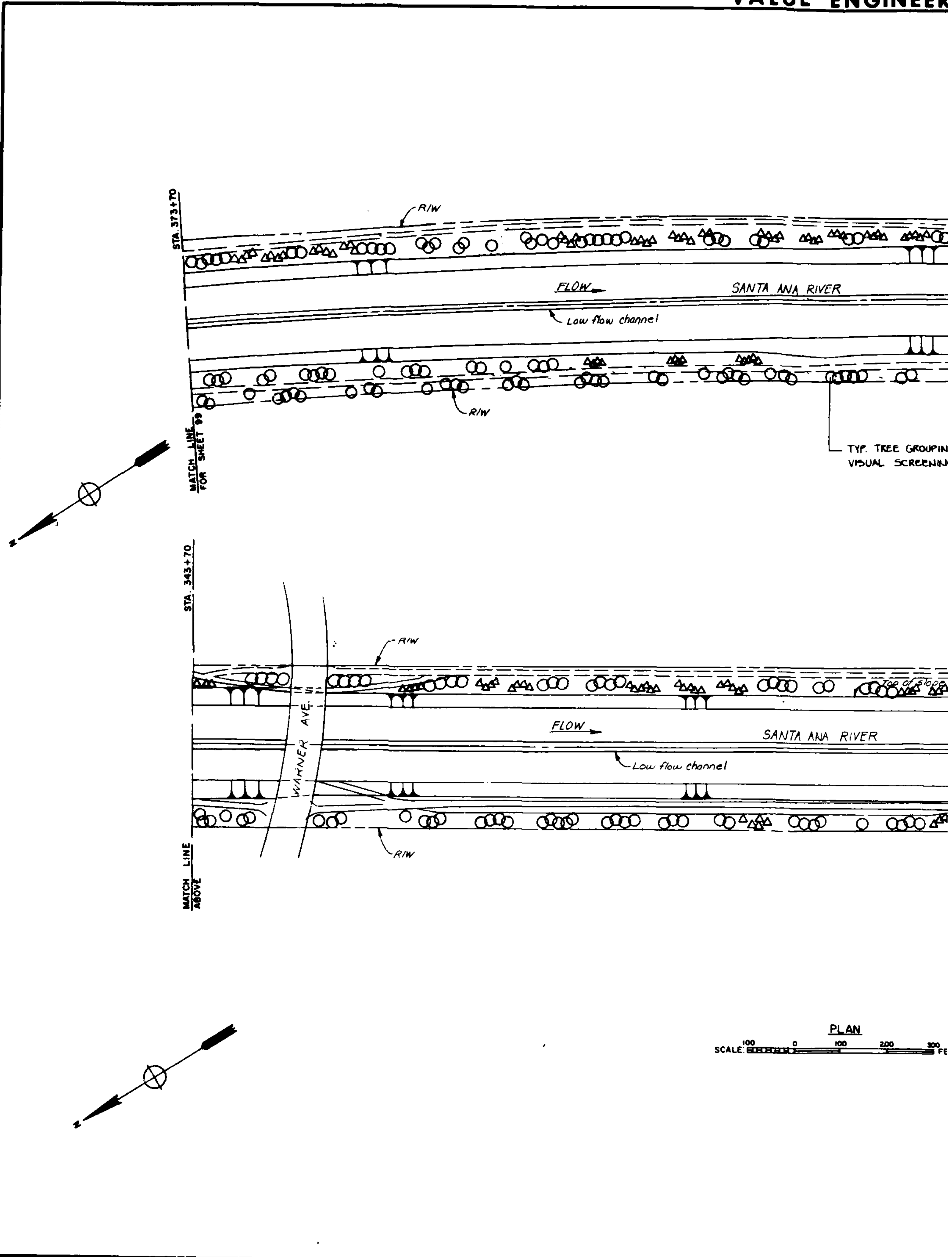
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER MAINSTEM CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA 435+50 TO STA 373+70

EDL
EDL

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



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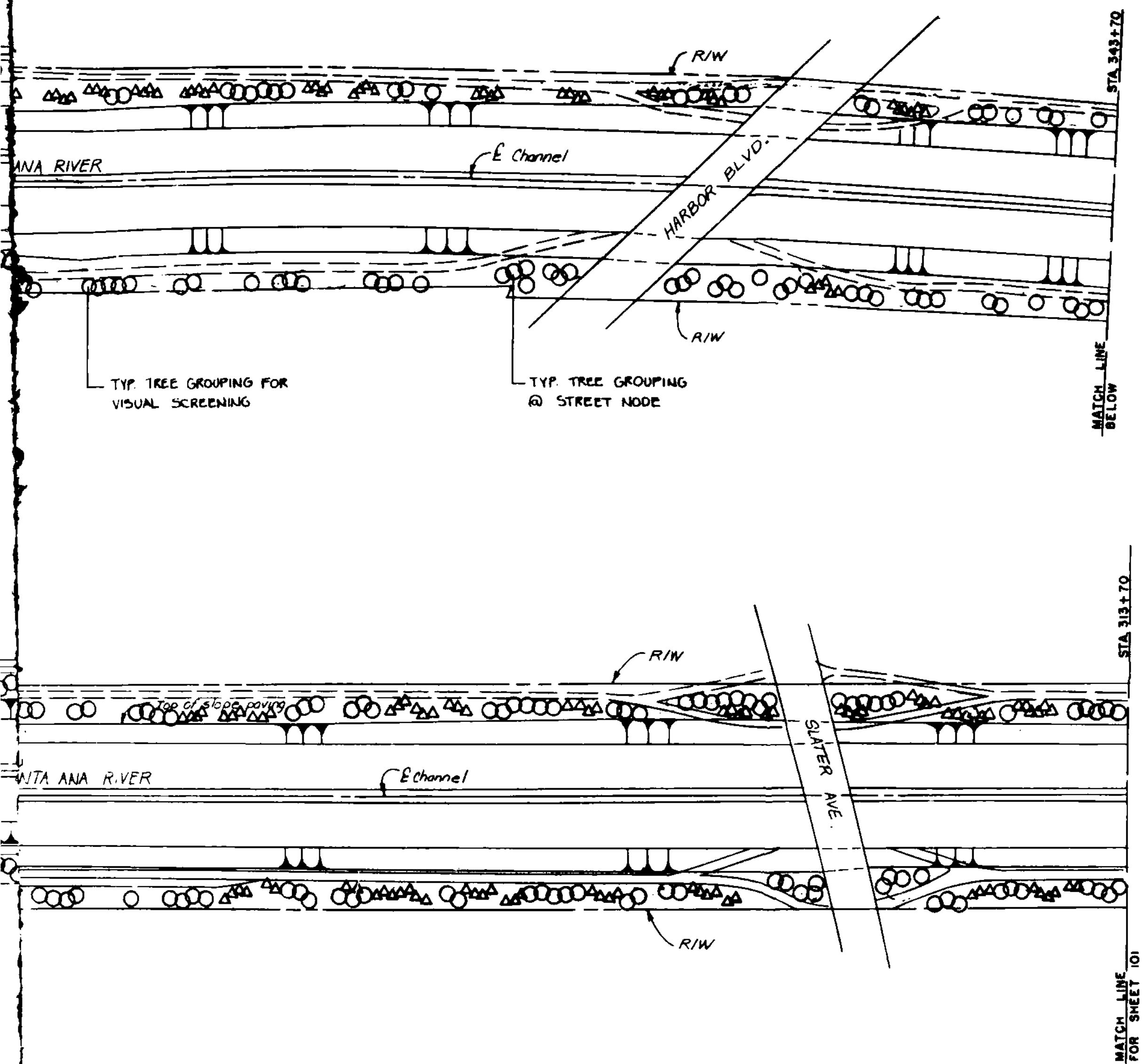


PLAN

0 100 200 300 FEET

LEGEND

TYPICAL TREE GROUPING

TYPICAL SHRUB GROUPING

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL

DRAWN BY: F. Castellanos EBL

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.373+70 TO STA.313+70

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

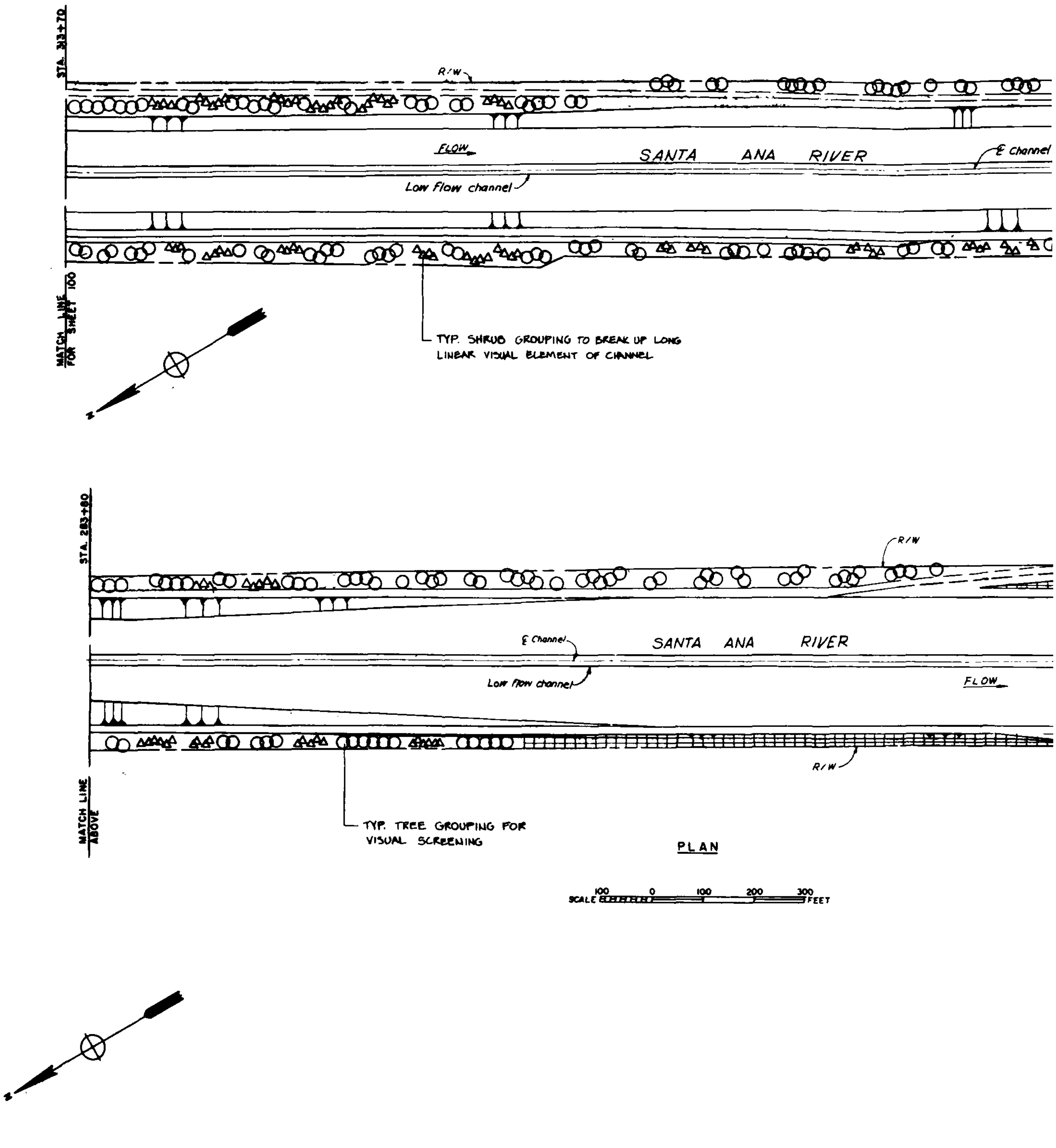
SHEET 100 OF 105 SHEETS

PLATE 108

SAFETY PAYS

2

ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING



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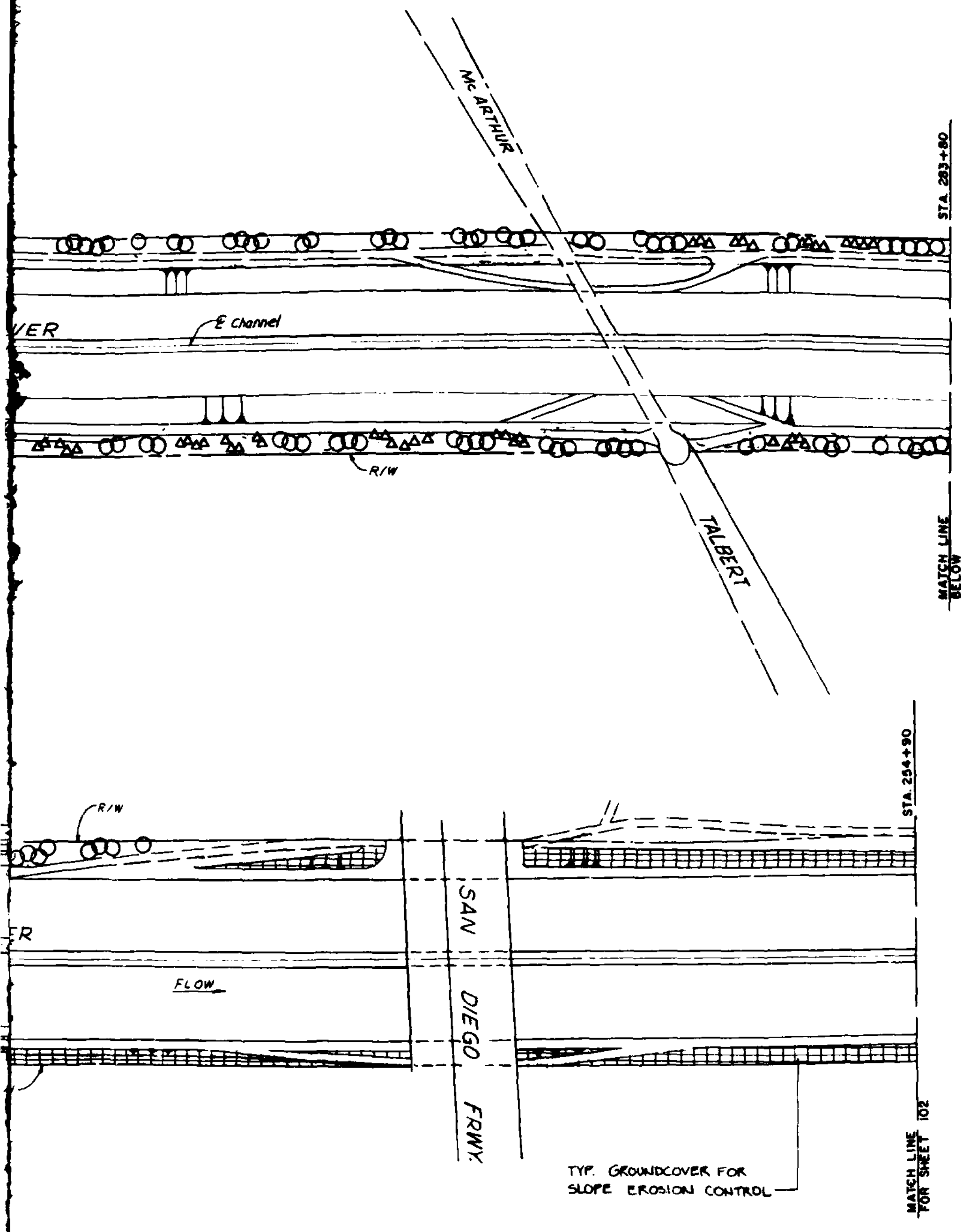


LEGEND

- TYPICAL TREE GROUPING
- TYPICAL SHRUB GROUPING
- TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL

DRAWN BY: H. Gies EBL

CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.313+70 TO STA.254+90

SUBMITTED BY:

DATE APPROVED:

DISTRICT FILE NO.

SHEET 101 OF 105 SHEETS

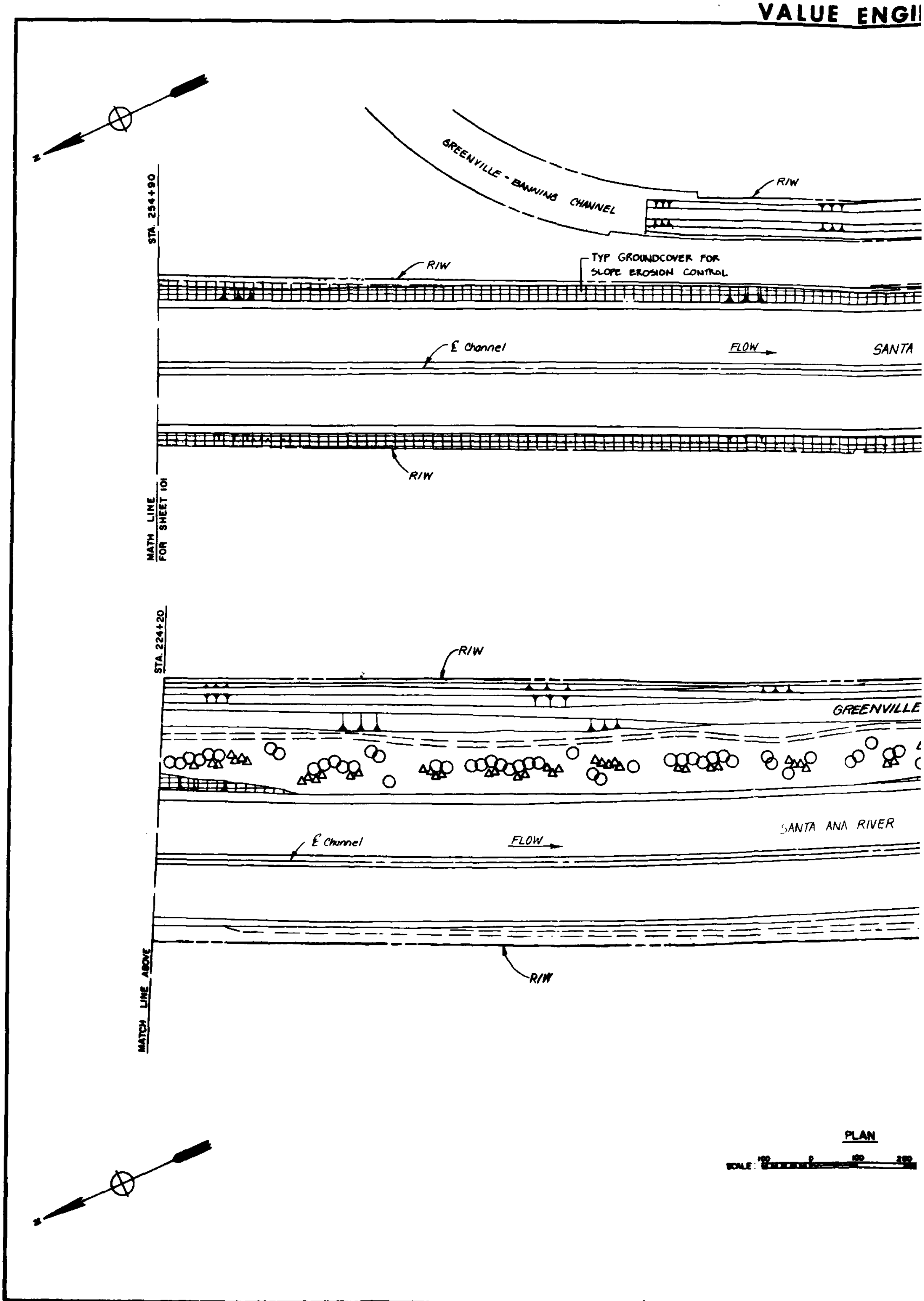
PLATE 104

1

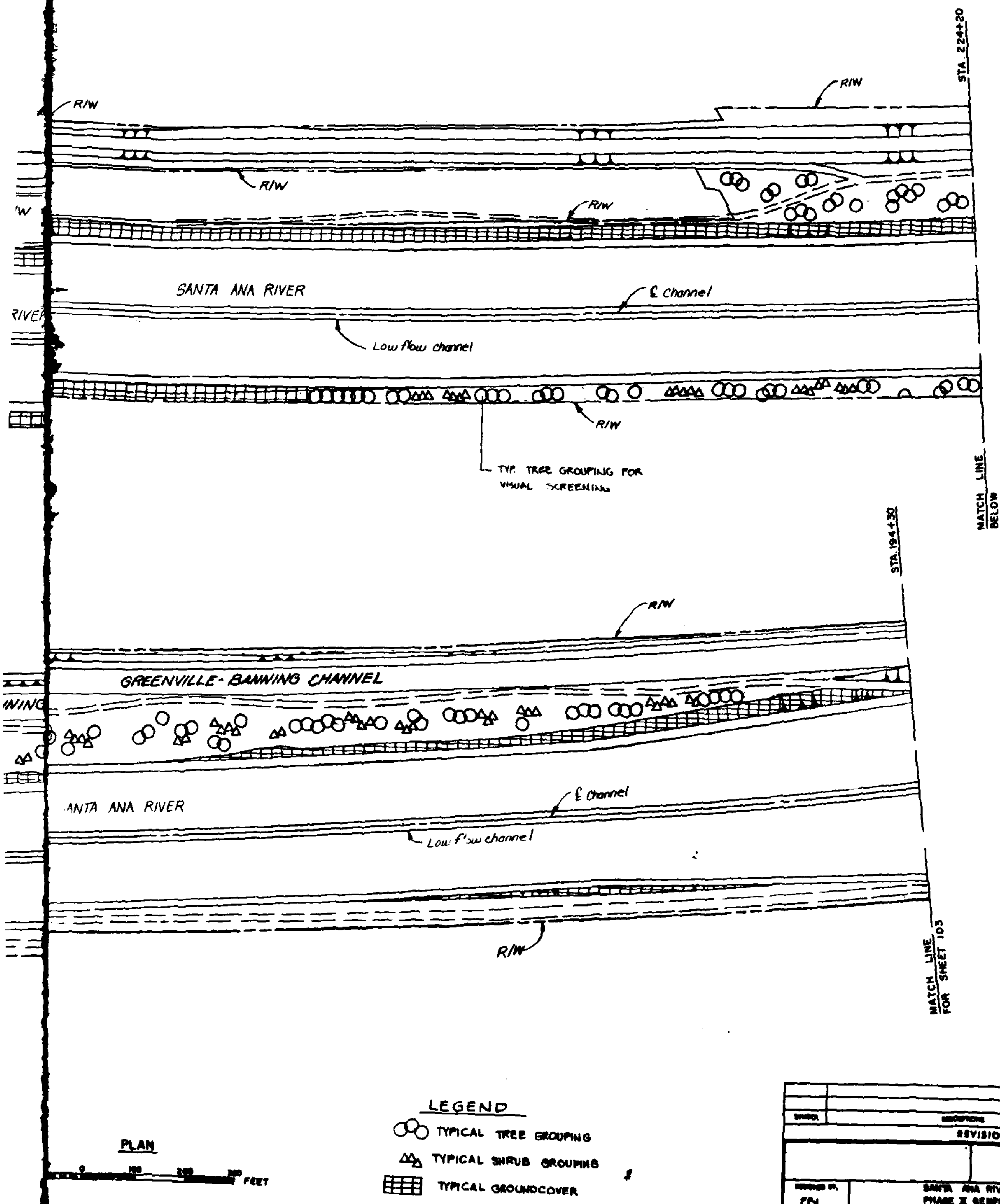
2

VALUE ENGI

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



VALUE ENGINEERING PAYS



REVISIONS

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

SANTA ANA RIVER BASIN, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.254+90 TO STA. 194+30

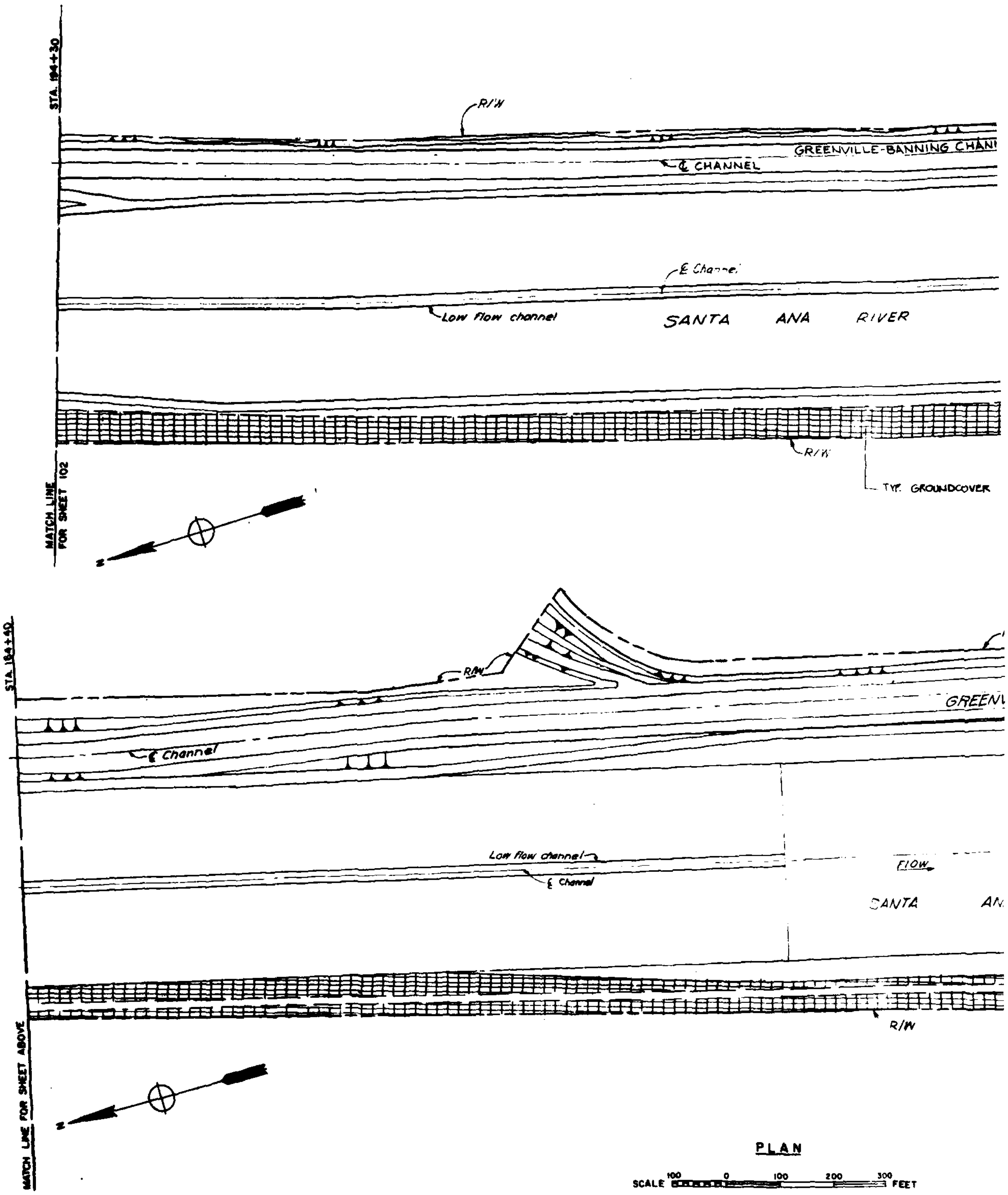
Designed by: CBL
Drawn by: CBL
Checked by:
Submitted by:
Date approved:
District file no.
Sheet 102 of 103

SAFETY PAYS

D

VALUE ENGIN

ENVIRONMENTAL
ENHANCEMENT
THRU ENGINEERING

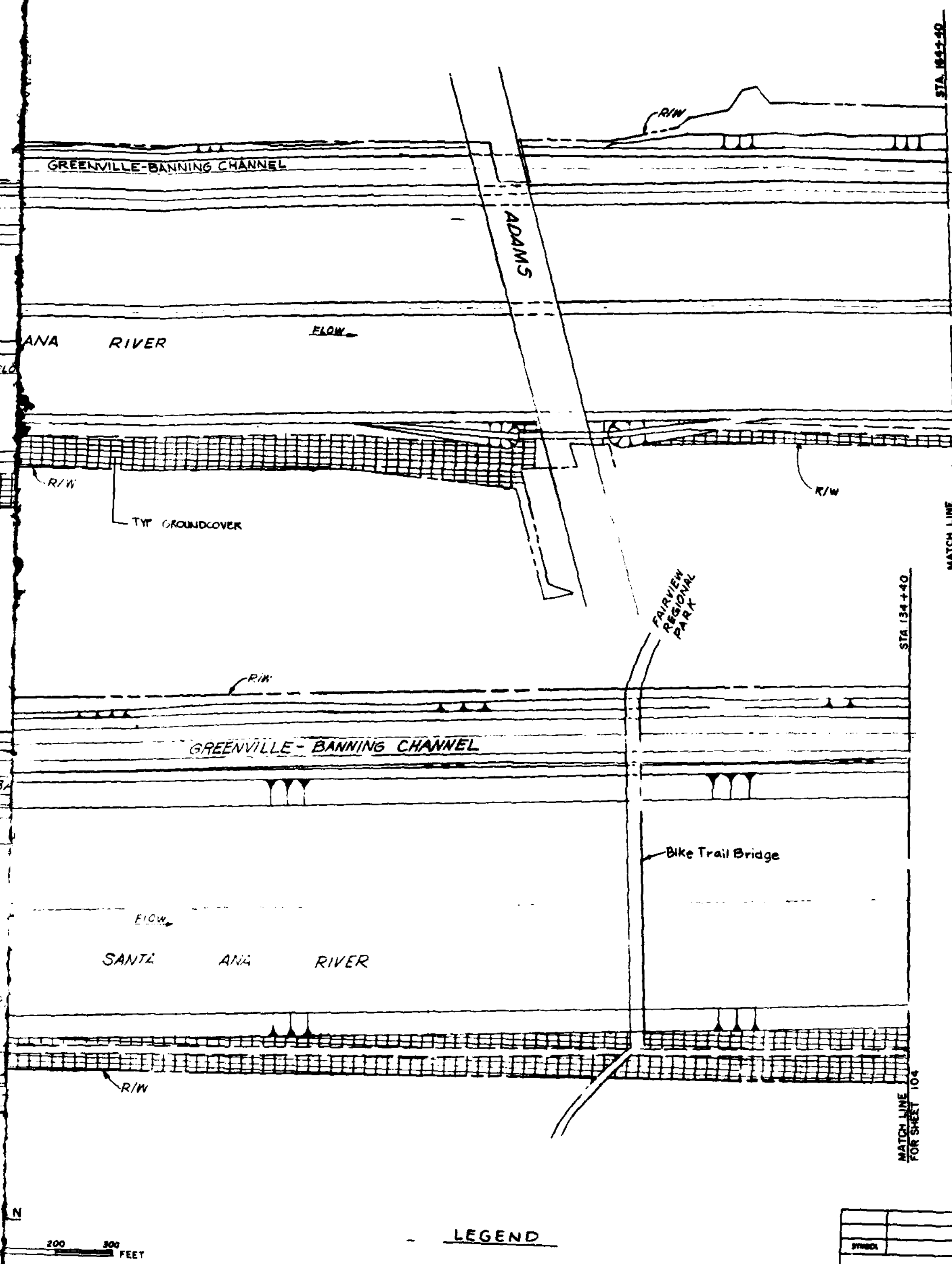


PLAN

SCALE 100 0 100 200 300 FEET

SAFETY

VALUE ENGINEERING PAYS



LEGEND

TYPICAL GROUNDCOVER

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL
DRAWN BY: H.A. EBL
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

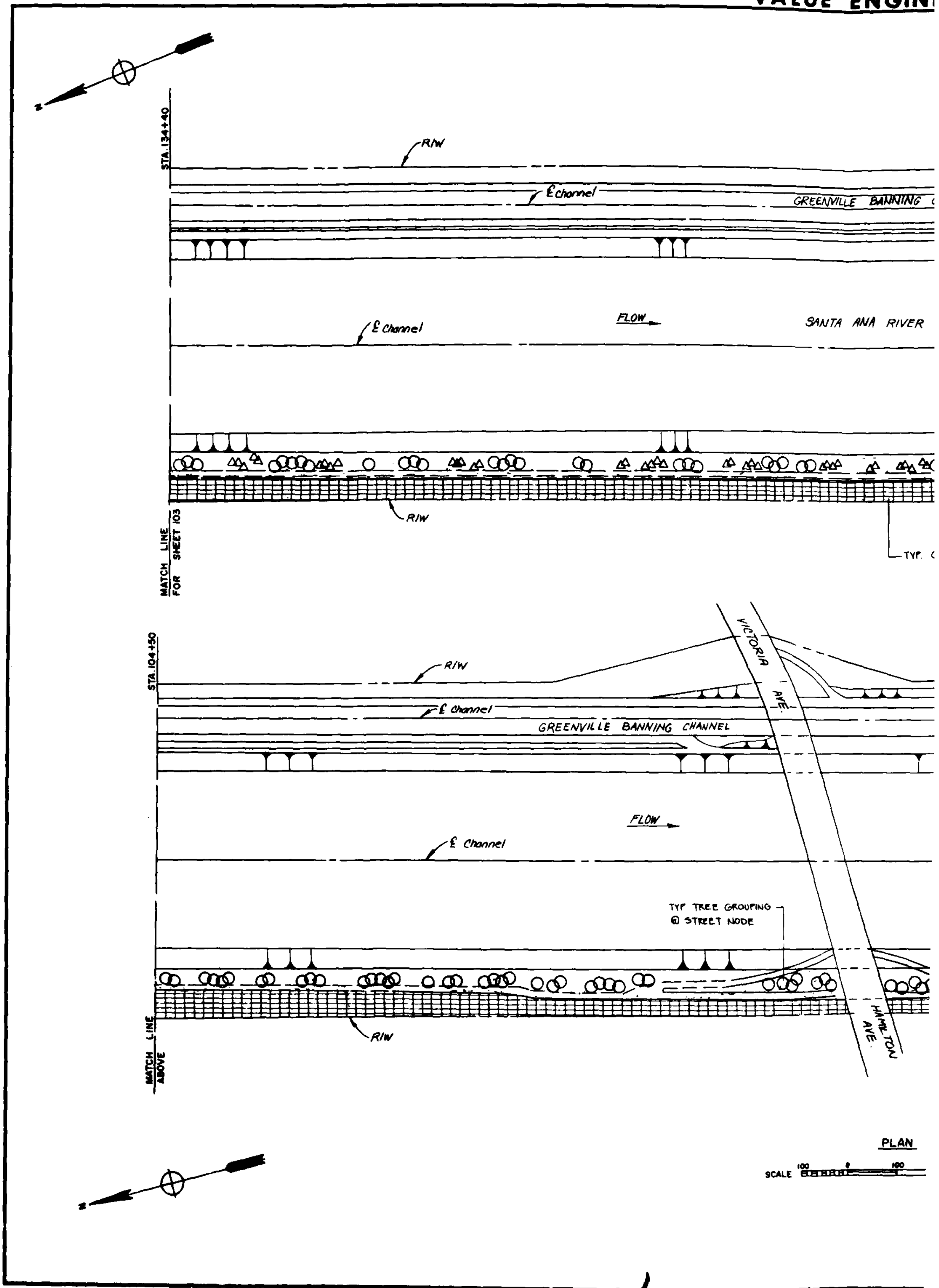
LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA 194+30 TO STA 134+40

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 103 OF 105

SAFETY PAYS

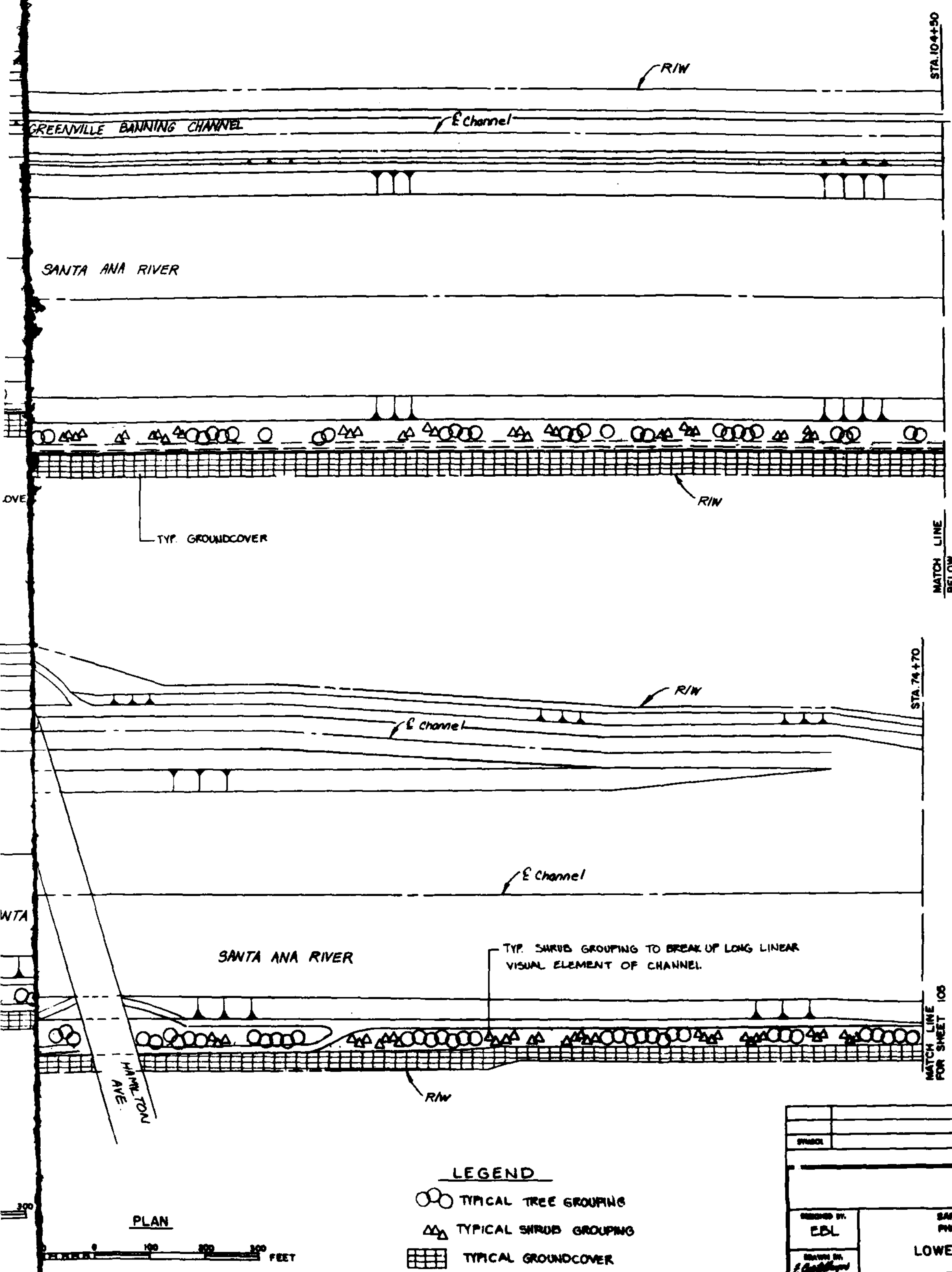
PLATE 10R

VALUE ENGIN



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

SAFETY



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL
DRAWN BY: EBL
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

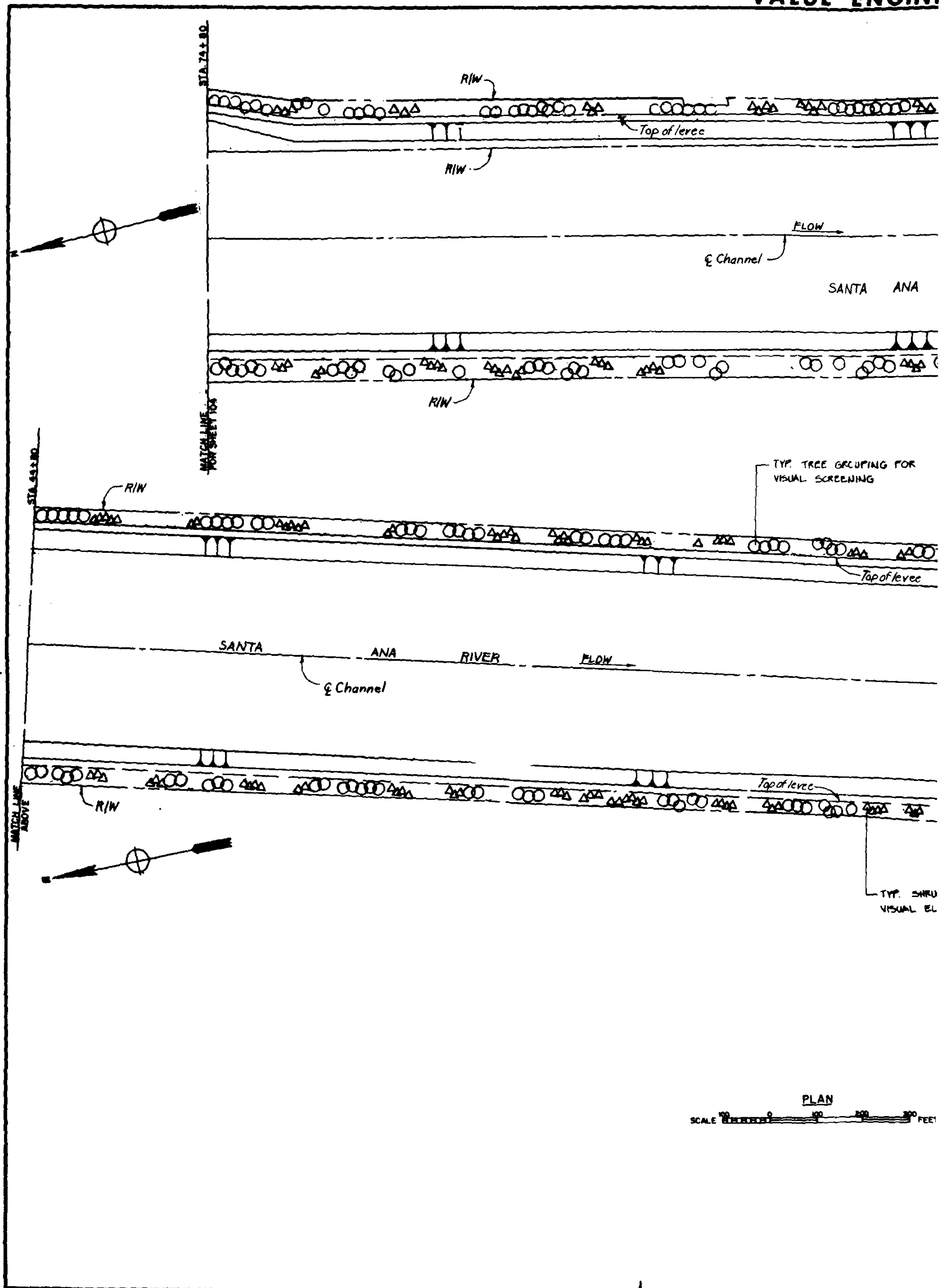
LOWER SANTA ANA RIVER CHANNEL
ESTHETIC TREATMENT PLAN
STA.134+40 TO STA. 74+70

SUBMITTED BY:
DATE APPROVED:
DISTRICT FILE NO.
SHEET 104 OF 105 SHEETS
PLATE 107

2

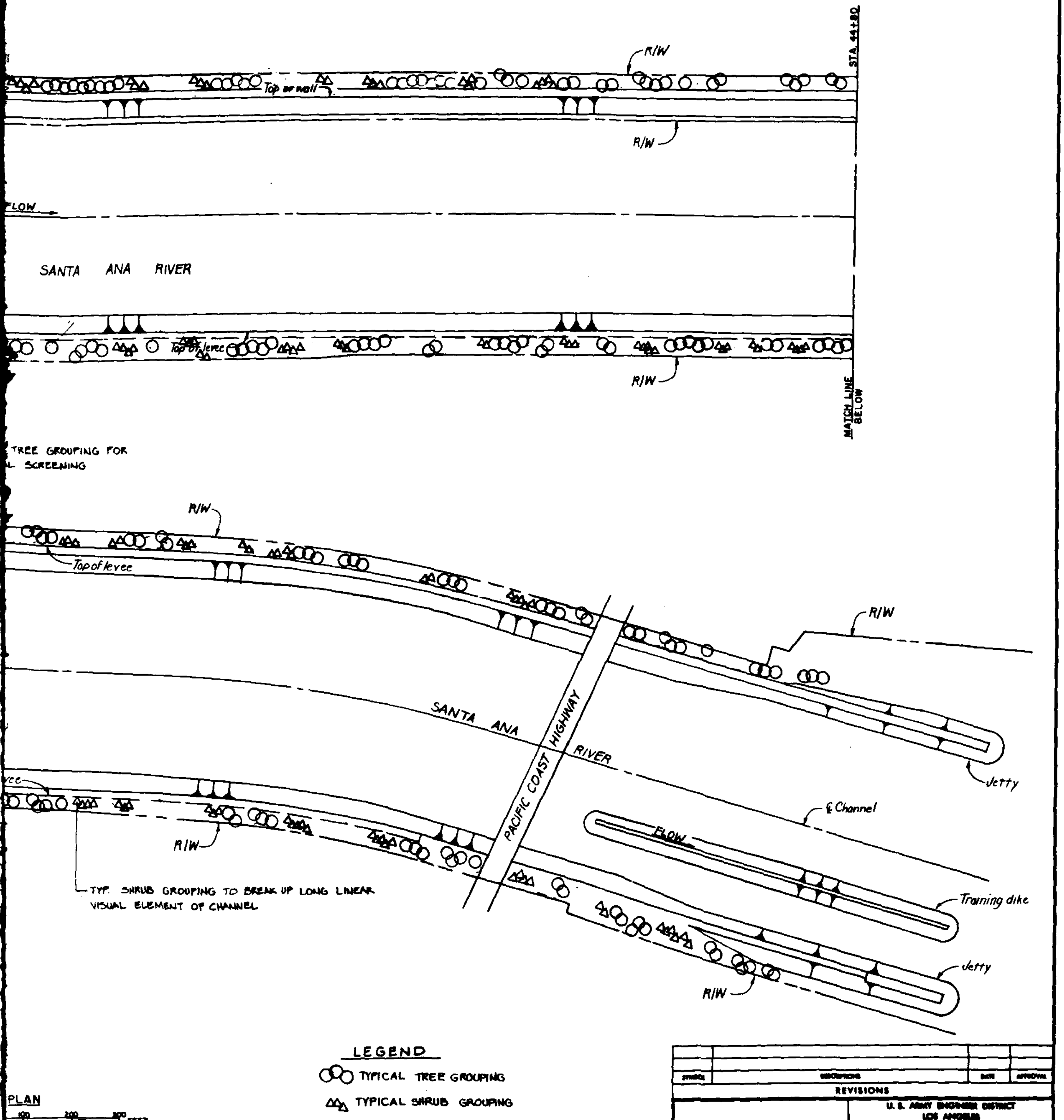
VALUE ENGINI

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING



SAFETY

VALUE ENGINEERING PAYS



SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: EBL
DRAWN BY: EBL
CHECKED BY:

SANTA ANA RIVER MAINSTEM, CALIFORNIA
PHASE II GENERAL DESIGN MEMORANDUM

LOWER SANTA ANA RIVER CHANNEL

ESTHETIC TREATMENT PLAN
STA. 74+80 TO STA. 84+30

SUBMITTED BY: DATE APPROVED:
DISTRICT FILE NO.
SHEET 106 OF 106 SHEETS

PLATE 106

SAFETY PAYS

END

DATE FILMED

--89

AD-A204 544 SANTA ANA RIVER DESIGN MEMORANDUM NUMBER 1 PHASE 2 GDM ON THE SANTA ANA R..(U) ARMY ENGINEER DISTRICT LOS ANGELES CA AUG 88 6/6

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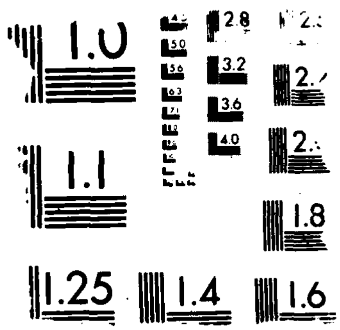
1.0
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1.1
1.8
1.25
1.4
1.6

SUPPLEMENTARY

INFORMATION

AD-A204 544

Errata

DESIGN MEMORANDUM NO. 1
PHASE II GDM ON THE SANTA ANA
RIVER MAINSTEM, INCLUDING SANTIAGO CREEK
DATED: AUGUST 1988

On November 15, 1988, the U.S. Army Corps of Engineers released, for agency and public review, the Congressionally authorized final General Design Memorandum (GDM) for the Santa Ana River Mainstem Project, including the Main Report and Supplemental Environmental Impact Statement, and accompanying volumes and technical appendixes. The Corps mailed copies of the final Phase II GDM to selected Federal, State, and local governmental agencies; elected officials within the project area; flood control districts; interest groups; and public libraries. Review of the final Phase II GDM by the agencies and the public generated comments which, in general, focused on the following concerns:

(a) Recreation trails along the Santa Ana River; (b) Aquatic habitat at Seven Oaks Dam; (c) Lower Santa Ana River sediment transport and potential beach degradation; (d) Esthetics and construction phasing for the Santiago Creek channel improvements; and (e) Flood threat and associated impacts to the Corona Airport within the Prado Dam. Inclosure 1 presents a synopsis of the U.S. Army Corps Engineers response to these concerns.

Following publication of the final Phase II GDM, several inconsistences were noted that require clarification of certain statements, and correction of typographical errors. The errata sheets (Inclosure 2) provide the revisions to be incorporated in the final Phase II GDM.

For additional information you may direct your inquiries to the following:

U.S. Army Corps of Engineers
P.O. Box 2711, L. A., CA 90053-2325
Attn: Mr. Dionicio Gonzales
Tel No. (213) 894-2713

Brian M. Moore
for
Tadahiko Ono
Colonel, Corps of Engineers
District Engineer

Encls

U.S. ARMY CORPS OF ENGINEERS
RESPONSES TO AGENCY AND PUBLIC REVIEW COMMENTS
ON
DESIGN MEMORANDUM NO. 1
PHASE II GENERAL DESIGN MEMORANDUM
ON THE SANTA ANA RIVER MAINSTEM, INCLUDING
SANTIAGO CREEK
DATED: AUGUST 1988

RECREATION TRAILS ALONG THE SANTA ANA RIVER

ISSUE - The Main Report and Supplemental Environmental Impact Statement indicated that the equestrian trails in several locations along the Santa Ana River would be a continuous paved surface. Comment was made that this would constitute an unacceptable conversion of use since the existing trails are unpaved.

RESPONSE - The Corps and Orange County, one of the sponsors, will be developing several alternative solutions in coordination with the National Park Service to resolve this issue. One solution would be to locate the trail along the toe of the levee, while a more promising one may be to use excess spoil material to widen the top of the levee within the existing rights-of-way. We anticipate that this issue can be successfully resolved.

AQUATIC HABITAT AT SEVEN OAKS DAM

ISSUE - Concern was for the need for additional mitigation measures to compensate for impacts on aquatic habitats at the Seven Oaks damsite.

RESPONSE - The recommended mitigation plan to compensate for impacts resulting from the Seven Oaks Dam portion of the project was evaluated, and project related impacts and achievable mitigation goals were defined. The evaluation indicated that the mitigation plan for Seven Oaks Dam will meet 14.5% of the mitigation goal for aquatic habitat. Following coordination with the various resource agencies, no mitigation options were found which would achieve 100% mitigation under current Corps policy on mitigation. The Corps agrees that the aquatic habitat is impacted and has identified the magnitude of the impact according to NEPA requirements. The Corps has considered all practicable mitigation options in fulfilling its 404(b)(1) requirements. The project has been determined to not be contrary to the public interest even though 100% mitigation of impacts is not achieved.

LOWER SANTA ANA RIVER - SEDIMENT TRANSPORT & BEACH DEGRADATION

ISSUE - Concern was for impacts of the project on coastal beaches and that the project does not assure commitments to mitigate for these adverse impacts.

RESPONSE - The concern was based on the statement in the SEIS, page V-57, paragraph 5-192, which stated that there would be a reduction in sediment available for beach replenishment as a result of the project. Upon close scrutiny of the aforementioned paragraph we find that the statements contained therein are erroneous and was inadvertently included in the SEIS. Volume 3, Lower Santa Ana River, presents results of the sediment transport analysis which indicates that there would be a net increase of 11,000 cubic yards of sediment per year available for beach replenishment with the project in place. Accordingly, the aforementioned paragraph in the SEIS will be revised to read as follows:

"Under existing channel conditions, large floods will breach levees causing flood flows and sediment to exit and deposit onto the Santa Ana River Flood Plain. With the project channel improvements, large flood flows (up to 190 year frequency) will remain in the channel, thus causing any sediment that would have been deposited in the floodplain to be deposited in the channel itself or conveyed to the ocean. With the Santa Ana River project in place, sand-sized sediment yield (average annual basis) is estimated to increase by 11,000 cubic yards."

The Corps has held several meetings with staff members of both the California Coastal Commission and the City of Newport Beach to resolve the issue of placement of compatible channel material on the beach. The discussions appear to be headed to a mutually acceptable agreement.

ESTHETICS AND CONSTRUCTION PHASING FOR THE SANTIAGO CREEK CHANNEL IMPROVEMENTS

ISSUE - The concern was raised regarding the channel design and construction phasing of Santiago Creek, and the associated esthetics impacts of the project.

RESPONSE - The design displayed in the report for the stabilization of Santiago Creek between the Santa Ana Freeway and the Santa Ana River reflects the minimum amount of construction required to reliably and economically protect the streambed and banks of the creek from erosion. This design was developed after carefully consideration of the desires of residents along the creek as expressed in numerous public involvement meetings, and as the result of detailed investigation of several alternatives. The Corps of Engineers cannot support any lesser level of improvement as being sufficiently reliable. If this reach of channel is not stabilized to the minimum level shown in the report, significant erosion of the stream banks with potentially disastrous damage to property immediately adjacent to the creek on both sides would occur during controlled design flood releases from the detention basin. If the reach of the Santiago Creek from the Santa Ana Freeway to the Santa Ana River is not sufficiently stabilized, the flood control project cannot be safely operated as designed. In regards to the construction phasing for Santiago Creek it is not advisable to construct the upstream flood control improvement <u>prior</u> to commencing

any construction downstream of the freeway because of the need to have the lower channel in place to operate the detention pits.

FLOOD THREAT TO THE CORONA AIRPORT WITHIN PRADO BASIN

ISSUE - Concerns were raised about the potential flood threat at the Corona Airport as a result of the Corps recommended modifications to Prado Dam.

RESPONSE - The Corps studies indicate that the recommended Prado modifications will enable us to make larger releases from Prado Dam, thus allowing faster drawdown of the flood control pool. Consequently, within the period of the current airport lease, the frequency and duration of flooding at the airport will be reduced with the recommended modification of Prado Dam. Should interests at the airport feel that a levee is imperative to protect the airport from frequent flooding while allowing impoundment during major storm events, they would need to identify a local financial sponsor to bear the full costs for the levees and for the costs for mitigative measures resulting from the construction of the levees. These costs are entirely non-Federal expenses. It is noted that the Corona Airport is located on lands owned by the Federal Government for the purpose of flood control and all investments in this location were made with the full knowledge of the flood threat. As our recommended modifications will not result in more frequent or longer durations of flooding, the Corps did not include flood protection features at this location.

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VOLUME 3

LOWER SANTA ANA RIVER

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1. Section III Figure 7. Design Flood discharge on mainstem channel of 47,000 cfs should be revised from "100-year" to "190-year."

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